Materials Methods®

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NEXT MONTH: Substitutes for Stainless Steels . . . High Temperature Resistant Ceramic Coatings . . . Evaluation of Forgings . . . Color Match Welding . . . Localized Flame Hardening . . . Materials for Photoelastic Stress Analysis . . . New Insulation Materials for Electric Motors . . . Preparing Zinc- and Aluminum-Base Die Castings for Electroplating . . . GLASS AS AN ENGINEERING MATERIAL (Materials & Methods Manual No. 68)

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Published in 1929 as Metals and Alloys.

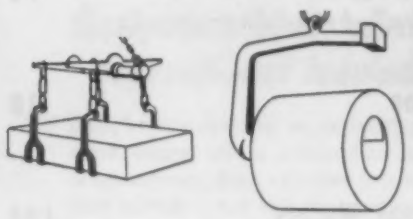
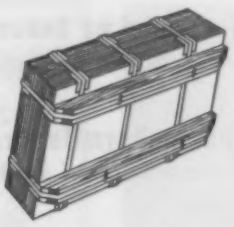
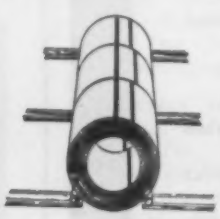
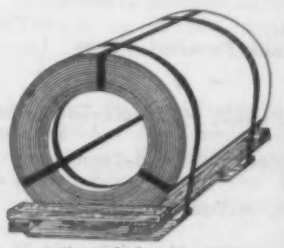
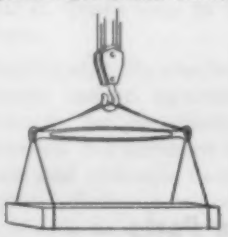
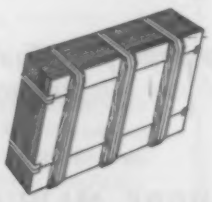
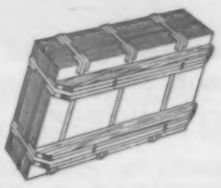
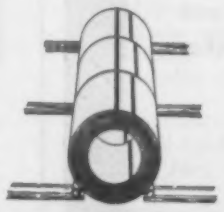
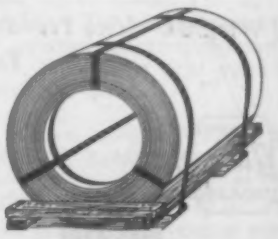
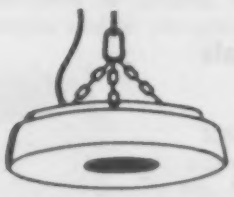
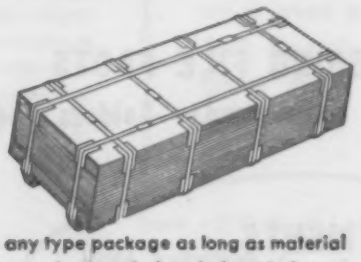
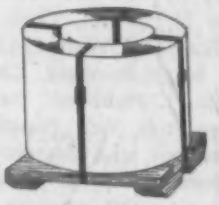
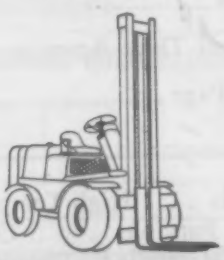
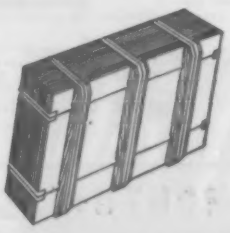
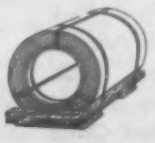
INLAND DATA for STEEL USERS

INLAND STEEL CO.

38 S. Dearborn Street, Chicago 3, Illinois

Packaging your Steel sheets and strip

One way the steel user may be able to reduce the cost of steel delivered to his fabricating equipment, is by specifying the correct type of package the mill should provide. In the final analysis, his handling equipment, storage facilities, method of transportation from mill to plant and end-use of the steel will all have a bearing on the type and weight of package he needs. The following chart illustrates the most generally used types of packages for steel sheets and strip. We are always glad to recommend to the user, the most suitable type of package for the steels we ship.

Type of handling equipment in steel user's plant	The most generally used types of steel mill packages	
	for cut lengths	for coils
Overhead crane with SHEET LIFTER or COIL HOOK 	 sheets on lengthwise skids	 cylinder method of loading coils  coil on skid, core horizontal
Overhead crane with CHAIN OR CABLE SLINGS 	 sheets on crosswise skids  sheets on lengthwise skids	 cylinder method of loading coils  coil on skid, core horizontal
Overhead crane with ELECTRO-MAGNET 	 any type package as long as material is securely banded or tied	 flat method of loading coils  coil on platform, core vertical
FORK TRUCK 	 sheets on crosswise skids	Ram truck or Fork truck used as ram  cylinder method of loading  coil on skid, core horizontal Fork truck  coil on platform, core vertical

The Materials Outlook

Although no one has definite information, indications in Washington now are that most durable goods will be produced during the first half of 1951 at a rate of about 20 to 30% under that of the same period of 1950. Shortages of certain materials and use limitations on others will probably cut production in some lines, but the overall defense production is scheduled to be something like 20% of our total production.

At the insistence of both government and industry, it now seems likely that a controlled materials plan (similar to the CMP of World War II) will go into effect as soon as possible. Best estimates place time of start of plan's functioning as July 1. Smart business men will be prepared for that program by establishing comprehensive, accurate and detailed materials lists of all products they are to manufacture—both defense and civilian goods.

Here, briefly, is the supply picture in plastics. Demand is now 25% higher than last year and growing. Further demand is anticipated both in direct war products and as metal replacements. Some raw materials are limited, barring a vastly increased output. Individually, the prospects are as follows:

Phenolics--A 20% production increase possible if phenol is made available.

Ureas and Melamines--New capacity will not be entirely sufficient to meet increasing demands.

Polyesters--Any substantial increase will require diversion from least essential uses or further expansion of basic raw materials (benzol, maleic anhydride, styrene, glycols).

Cellulosics--Supplies expected to improve after second quarter of this year. Film (packaging) will continue scarce.

Vinyls--Demand exceeds supply by 25%. Expansion underway, but needed chlorine might hold down production. Vinyl acetate and resins based on alcohol and butyral are extremely critical

Styrenes--Little chance for improved supply during 1951.

Acrylics--Now short, but supply is sufficient for most essential needs.

Polyethylene—Increase in production of 100% expected by end of 1951, but potential defense needs might absorb entire supply.

Copper, zinc, nickel and chromium as well as steel will all be saved if and when automobile output is cut. In addition, most automakers have indicated to their dealers or

(Continued on page 4)

The Materials Outlook *(Continued)*

suggested in their literature that much of the plated bright work will soon be missing from new cars. Important savings in plating materials will thus be made to keep within limitations imposed by NPA regulations. The ban on nonessential uses of nickel will speed auto trim conversions.

A new combination extruding-forging process for making tapered aluminum wing spars for aircraft appears to be highly successful. Not only does the new shape, weighing 117 lb, replace about 50 separate parts, but it also cuts down the weight of fighter planes by about 50 lb.

For the next several months limitation orders on the use of materials will come so thick and fast that it will be a full time job keeping up with them. The anticipated CMP will help restore order. In the meantime, prudent business men will have to be prepared to shift from one material to another with the facility of a trapeze artist.

Anticipated orders will affect molybdenum, tin and aluminum.

If we have all out war there is a strong likelihood the military demands would require an increase of 10 to 100 times in our capacity to produce iron powders. One big use would be to replace copper in rotating bands. Iron stands up better under conditions imposed by today's ordnance with high muzzle velocities.

The magnesium situation shows some signs of improving due to the reactivation of standby plants. These plants are expected to provide about 200,000,000 lb during the next two years for stockpile purposes. First metal from the reopened plants is expected within a few months.

A new high temperature metal coating material developed by an automotive company will be announced within the next few months. Tests show that the material, which is applied and which sets at room temperature, will serve for long periods at temperatures up to 1100 F without flaking or blistering.

Great things are expected of a newly developed stabilized zirconia refractory now becoming available. The material is useful at temperatures in the range of 4300 to 4700 F. In addition to being made as standard bricks, the zirconia can be produced in shapes for special purposes. Chief uses, as of now, are expected to be in the chemical and petroleum industries.

As to the copper outlook for 1951, a NPA spokesman recently stated that the overall supply would be at least 10% under that available in 1950. The normal pipelines have been emptied.

News Digest

French Extrusion Process to Be Used Here

What is believed to be the first American commercial application of the extrusion process for the manufacture of seamless steel tubes will be made upon the completion of new installations in the Gary, Ind., plant of the National Tube Co.

Employing the recently developed French Ugine-Sejourney process (see MATERIALS & METHODS, March 1950, pp 56-58) for the hot extrusion of metals, the company expects to be producing 3000 tons of special tubes and shapes per month before the en l of 1951.

The new production equipment, which includes a 2500-ton hydraulic extrusion press, is capable of turning out tubes ranging from 1½ to 6½ in. in dia, with wall thicknesses up to ¼ in. and lengths as great as 60 ft, as well as various shapes and bars from ½ to 4½ in. in cross sectional dimensions.

RFC Offers Bearing Alloy

A tin-antimony-copper-lead alloy called Copan is now being offered for sale by the Reconstruction Finance Corp. A by-product of Government tin refining operations, Copan is composed of 80 to 90 tin, 10 to 15 antimony, 2 to 5 copper, and less than ¼ of 1% of lead, making it suitable for a bearing material. Current quoted market prices for the tin and antimony, less a discount in each case, will be the basis for fixing the price of Copan, but further discounts will be allowed for carload purchases.

Results of Past Year's Research Revealed by Illinois Tech

Several findings of special interest to materials engineers resulted from the 150 widely varied research projects described in an annual report issued recently by the Armour Research Foundation of the Illinois Institute of Technology.

Titanium-Base Alloys

With the ultimate objective of developing titanium-base alloys with outstanding mechanical properties, considerable research was conducted on phase diagrams of the binary systems of titanium with silicon, columbium and molybdenum. Because of the reactive nature of titanium-base alloys at high temperatures, samples were prepared by melting in either nonconsumable or consumable electrode arc melting furnaces, using a protective atmosphere of argon. In addition, techniques were developed for heat treating the alloys and determining the melting point without contamination from the atmosphere.

Molybdenum Steels

Another investigation dealt with the effects of molybdenum and phosphorous on the toughness of incompletely hardened AISI 5140 and 1340 steels. In the slack quenched steels, as in steels fully hardened to martensite before tempering, a progressive decrease in toughness was observed as the phosphorous content was raised within commercial limits for open hearth alloy steels. When molybdenum replaced part of manganese or chromium in these grades, the effect of phosphorous was counteracted to a marked extent, especially when the steel was cooled slowly before tempering. The demonstrated ability of molybdenum to neutralize embrittlement caused by phosphorous is important at existing phosphorous levels, and will assume even greater significance in the event it becomes necessary to use higher phosphorous ores.

Stress Corrosion Cracking

Initial studies of the little-understood mechanism of stress corrosion cracking are now under way at the Armour Research Foundation using the 6% aluminum-magnesium-base alloy, which is particularly susceptible to stress corrosion. A new method for studying corrosion processes which employs an oscilloscope to reveal the distribution of electrical currents over the surface of a corroding specimen is expected to aid greatly in the investigations.

Impact Loading Effects on Steel

The ductility of steel under conditions of severe restraint, as imposed in the V-notch Charpy impact test, is the subject for a study designed to untangle the many metallurgical factors that are involved. Current phases of the work, now being published, include papers on the effect of ferrite grain structure and prior austenite grain size. Results of the investigation of the ferrite grain structure effects are believed to offer an explanation of the superiority of tempered martensite when compared to other steel structures. The consistently good performance of unembrittled tempered martensite apparently resides in its structure of small, inter-

(Continued on page 8)

News Digest

locking, needle-shaped ferrite grains.

Whether prior austenite grain size influences impact properties of heat treated steels has not been established. Only when the individual brittlement of heats is taken into account and a wide range of hardness examined can the effects of austenite grain size be clearly seen.

Possibilities of New Copper Mine Investigated in Michigan

The Defense Minerals Administration now has several investigators checking on a Michigan copper mine project that may involve a $100,000,000 Government loan. Located in Michigan's upper peninsula, the White Pine Property, site of the proposed mine, is said to contain the largest undeveloped copper ore body in North America.

Spokesmen for the Copper Range Mining Co., which owns the property, estimate that the Government loan would make possible the annual production of 75,000 tons of copper from the mine within three years. This would be more than 10% of the entire domestic production at present.

Government Approves Construction of Steel Plant

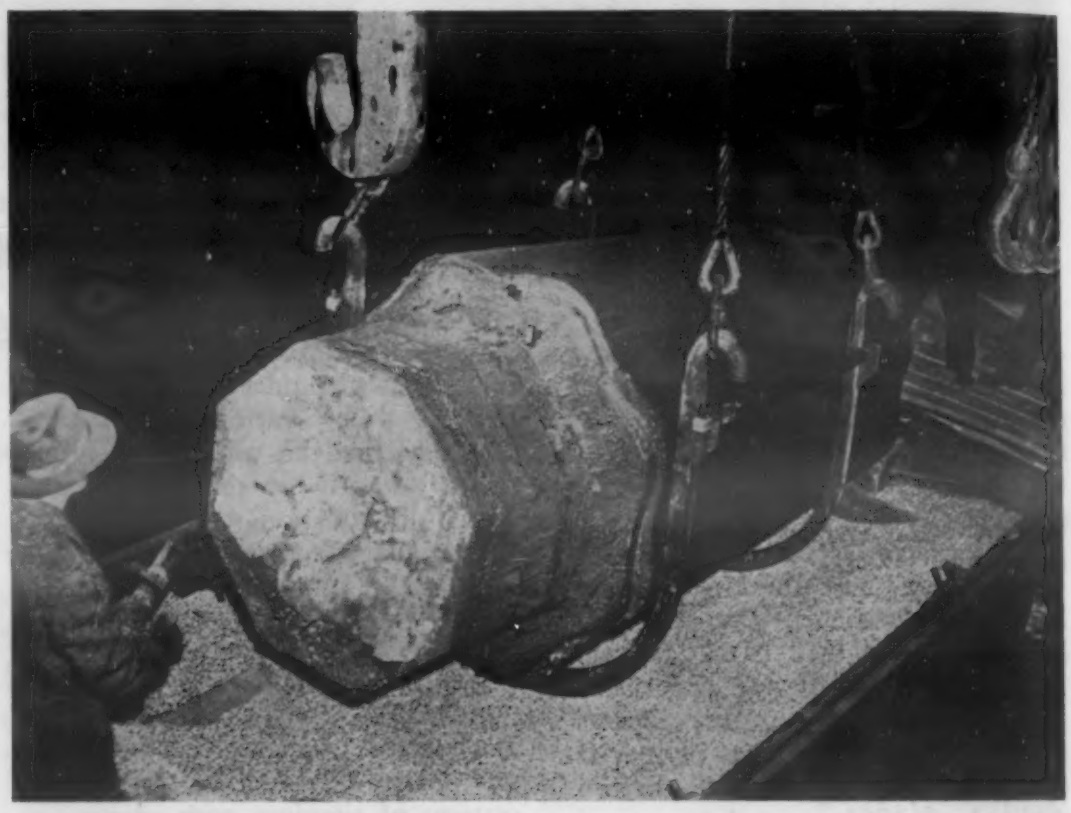
Approval for the construction of a $250,000,000 steel plant in the New London-Waterford area of Connecticut has been given by the Government. A certificate of necessity, issued by the National Security Resources Board, will enable the New England Steel Development Corp. to write off the cost of the new plant, for tax purposes, in five instead of 20 years. The proposed mill, for which financing must be arranged either through private or Government sources, would have a capacity of 1,000,000 ingot tons per year, processing from the ore to the finished product.

White-Hot Ingot Shipped 200 Miles

By shipping 130,000-lb ingots 200 miles by rail while they are white-hot, two Canadian steel companies have reduced the time ordinarily required to process such large masses of metal by nearly two months.

Before this time-saving idea was conceived, these ingots were cast at the Dominion Iron and Steel, Ltd. plant and allowed to cool for six weeks before being shipped to the Trenton Steel Works, Ltd., 200 miles away. At the Trenton plant, the ingot had to be reheated for 10 days before work could be continued. Under the new plan, however, the ingot is allowed to solidify in a mold at the Dominion plant. Then, while still white-hot, it is stripped and placed in a cast iron box insulated with premolded vermiculite, a mineral of the mica family. The remaining space is filled with loose vermiculite and a steel lid placed on the box. The cast iron box is then securely fastened to the floor of the railway car.

In the first test shipment, the ingot left the Dominion plant at a temperature of 1770 F late in the afternoon. When the Trenton plant began work on it the next morning, its temperature was recorded at 1575 F. Aside from reducing processing time, which results in lower costs, the shipping of hot ingots eliminates the danger of crack formation during cooling between the processing operations.



A 130,000-lb. white-hot ingot is lowered into a Canadian National car at Sydney, Nova Scotia, for a 200-mile trip to Trenton, N. S. Shipping the ingot hot saves nearly two months of processing time.

German Aluminum Delivery to U. S. Delayed

Italian Production Rises

Negotiations between American and West German firms for the delivery of 100,000 tons of aluminum to the U. S. have been delayed indefinitely by a serious shortage of electric power in Germany, according to the British publication, *Metal Industry*. Present production of the three German foundries at Toeging, Rheinfelden and Luenen, which have a yearly capacity of 85,000 tons, is reported to be insufficient to meet even domestic demands.

In fact, German sources say that imports of at least 8,000 tons are now

(*Continued on page 148*)

Frictional, Wear Properties Evaluated for Powder Metallurgy Bronzes

Powder metallurgy friction materials have become important in the heavy-duty brake and clutch fields in recent years. When such materials are run against opposing surfaces of steel or cast iron, coefficients of friction from 0.25 to 0.50 are acceptable and wear rates up to 0.010 in. per hr are considered satisfactory. Powder metallurgy materials used today are essentially alpha bronzes to which other components are added to produce desirable performance characteristics. The effects of such additions upon the frictional and wear characteristics of powder metallurgy bronzes were discussed by J. H. Dedrick in the *ASTM Bulletin,* October, 1950.

Graphite, Silica Additions

The author found that if more than six parts by weight of −325-mesh graphite or more than three parts by weight of −325-mesh silica are added to 100 parts of a 90 copper-10% tin bronze, values for coefficients of friction and wear rates are obtained which fall within the commercially acceptable range. This result holds up to 15 parts by weight of either addition. The silica-containing bronzes which produce acceptable wear rates have a coefficient-of-friction range from 0.40 to 0.55, but one serious objection to their use is that frictional operation is exceedingly noisy. And graphite additions which insure acceptable wear rates limit the coefficient of friction to about 0.34.

In small amounts, molybdenum sulfide additions appear to be more effective than graphite in reducing wear and friction. In larger quantities they are less effective than graphite in reducing wear but more effective in reducing friction. Because of the relatively high wear rate, it seems inadvisable to substitute molybdenum sulfides for graphite.

More Complex Alloy Needed

According to the author, lead additions to a basic bronze do not seem to be as effective as graphite or molybdenum sulfide in decreasing friction and wear. Coefficient of friction range obtained for the compositions tested was 0.47 to 0.28, but the wear rate was above the acceptable range in all cases. Thus, only the graphite addition appeared to have desirable effects, and even it was satisfactory only for coefficients of friction in the lower part of the useful range.

A more complex material, specifically a graphite-lead bronze base composite commercial alloy, showed a coefficient-of-friction range of 0.24 to 0.36—still too low for a "high-friction" material. However, additions of silica in varying amounts to such alloys were found to raise coefficient-of-friction values to the higher acceptable range (0.40 to 0.50) with accompanying satisfactory wear rates. In contrast to the bronzes containing silica alone, such materials operate relatively free from vibration and noise.

New Material Hardens When Removed from Air

"Anaerobic," a term which means "non-airliving", has been borrowed from the biologists to describe a new material which remains liquid as long as a stream of air bubbles through it, but which hardens when away from air.

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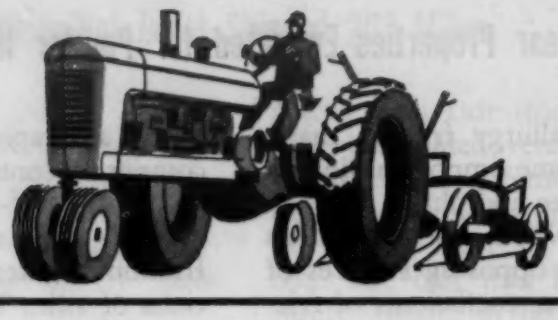
Developed in the chemistry divisions of the General Electric Research Laboratory, anaerobic permafil is the latest in a series of related liquid compounds which polymerize and harden fully without the necessity of any liquid evaporating. Although this is generally accomplished by heating or adding catalysts and accelerators to speed the process, the new permafil requires no aid in solidifying quickly when away from air.

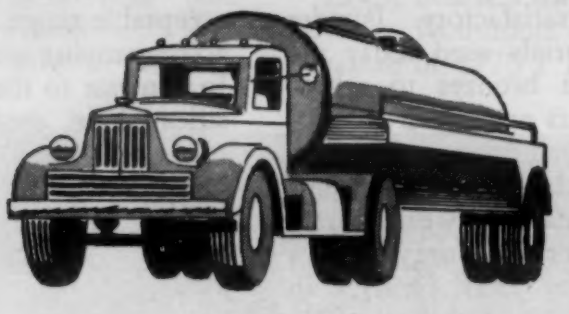
When two metal strips are coated lightly with the new material and clamped together, the joint will support 10 lb after 10 min and 100 lb after 20 hr. If even faster hardening is desired, however, the permafil can be heated as high as 212 F, at which

(*Continued on page 154*)

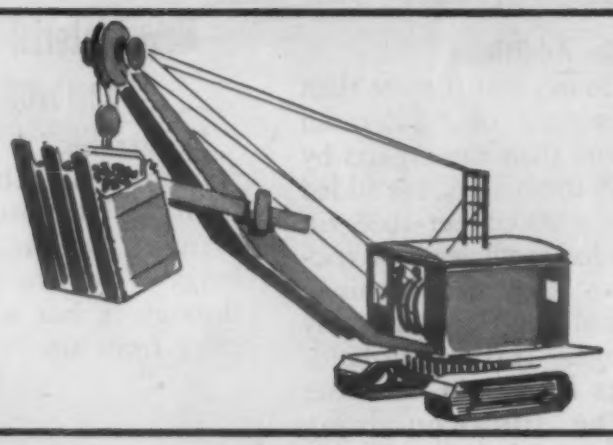
make it
STRONGER



make it
LIGHTER



make it
LAST LONGER



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HI-STEEL IS TOUGH. Nearly twice the yield point of structural grade carbon steel. Higher notch toughness, fatigue strength, abrasion resistance.

HI-STEEL IS DURABLE. Its tight scale resists atmospheric corrosion four to five times as long as ordinary structural grade carbon steel—and has been known to perform 12 times as long under abrasive conditions depending on the abrasive medium.

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News Digest

temperature solidification takes place in a minute or less.

Certain metals, such as copper, iron and silver solder, exert an accelerating action on the hardening process—even at room temperature

Dr. Robert E. Burnett demonstrates the properties of "anaerobic permafil," a material which hardens when away from air. In this test, it was applied to the surface of two strips of metal, which were then clamped together. Thirty minutes later the metal strips easily supported a 16-lb metal block.

—and can be sealed more quickly than surfaces of inert materials, such as glass and mica.

Anaerobic permafil is still the subject of experimental investigation, and only limited laboratory quantities are being produced at this time.

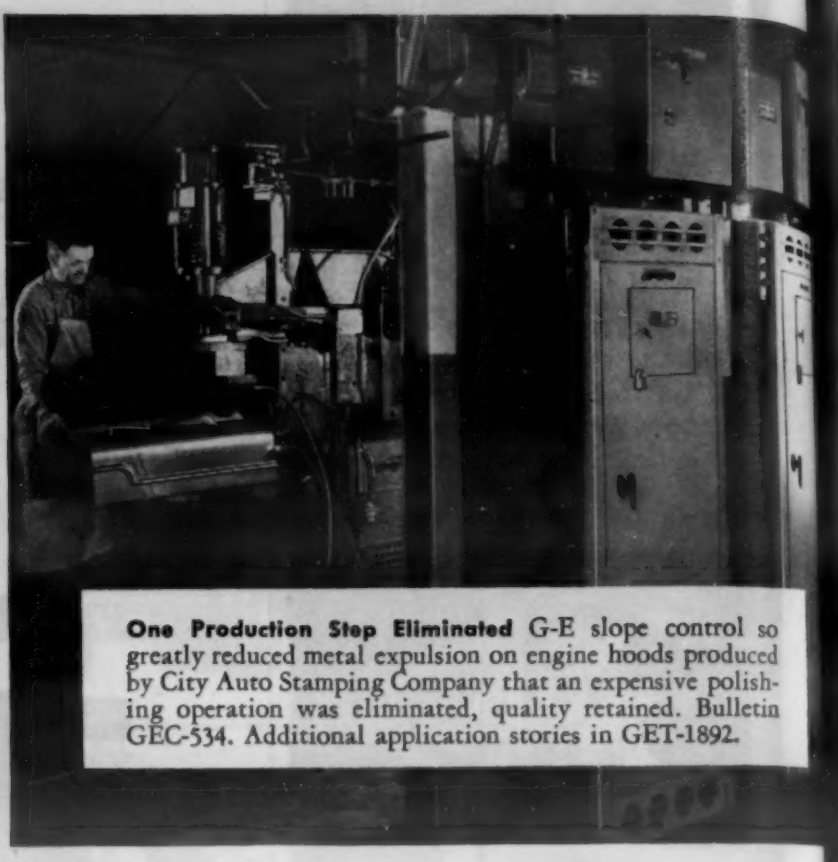
U. S. Develops Own Cobalt Sources

Domestic and Canadian ores will supply the United States with 4¼ million lb of cobalt annually by the end of 1952, according to a recent article in *Mining Engineering*. This compares to the pre-Korean annual U. S. cobalt consumption of 8 million lb—90% of which was imported from the Belgian Congo.

For the past 10 years, the only steady source of cobalt in the U. S. was the iron pyrite that accompanies the magnetite mined at Cornwall, Pa. From this cobalt-bearing ore, the

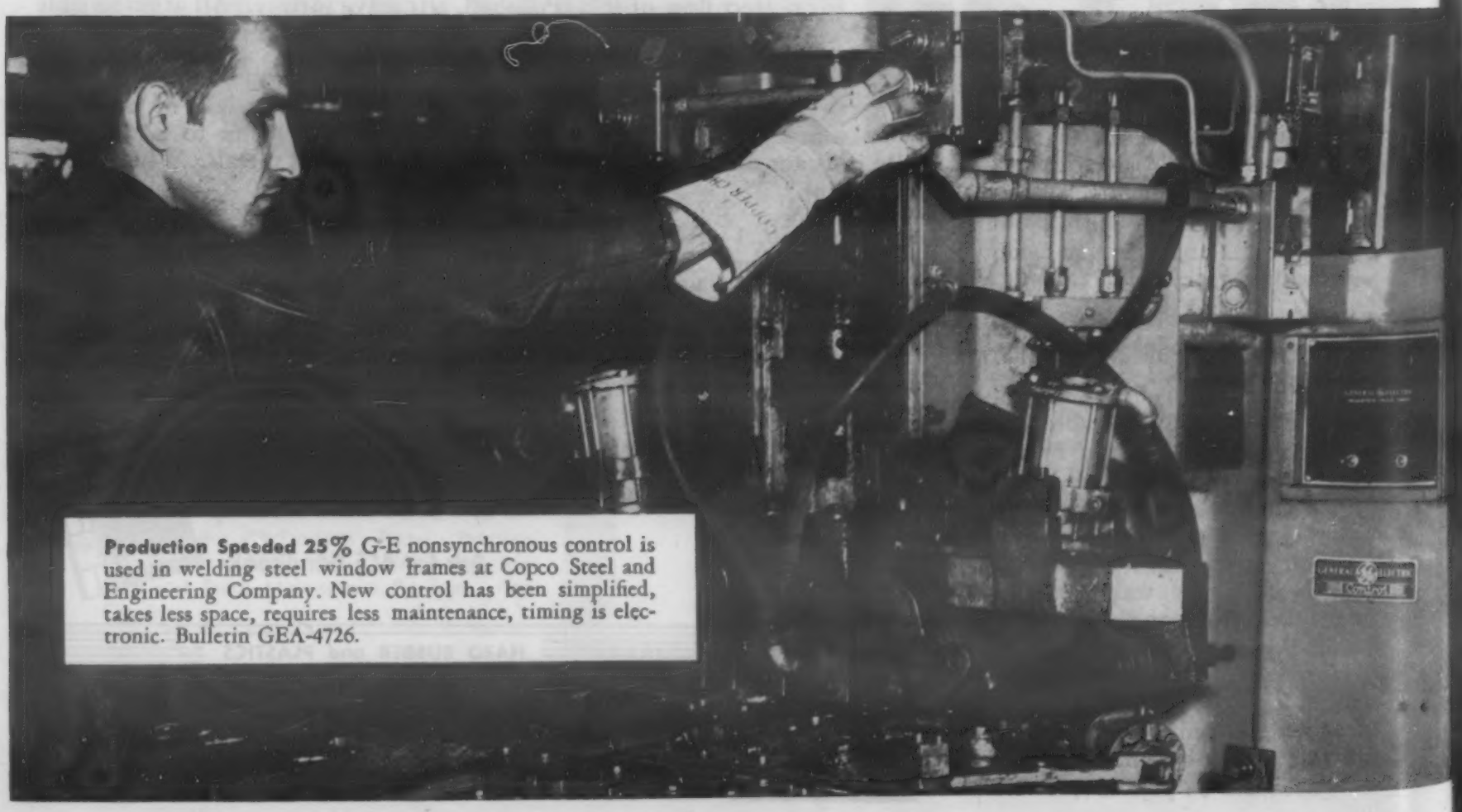
(*Continued on page 154*)

New Alloy Welded—just .007 inch thick G-E Thyratron spot-welding control is used at the Elgin National Watch Company on a Dura Power mainspring. Elgin reports, "Thanks to G-E control, work is easy, accurate, and production is high." Bulletin GEA-4175A.



One Production Step Eliminated G-E slope control so greatly reduced metal expulsion on engine hoods produced by City Auto Stamping Company that an expensive polishing operation was eliminated, quality retained. Bulletin GEC-534. Additional application stories in GET-1892.

LOOK!



Production Speeded 25% G-E nonsynchronous control is used in welding steel window frames at Copco Steel and Engineering Company. New control has been simplified, takes less space, requires less maintenance, timing is electronic. Bulletin GEA-4726.

Titanium Rapidly Growing as Useful Engineering Material

by W. T. TIFFIN and P. C. HOFFMAN, University of Florida

Titanium, with its excellent combination of properties, is a most valuable addition to the engineer's range of structural materials. This article reviews its progress to date, and outlines its present and future applications.

• ONE OF THE MOST significant present-day developments in the field of metallic materials is the emergence of titanium and titanium alloys as useful engineering materials. Titanium is about two-thirds as heavy as steel, weighs 283.5 lb per cu ft, and is a little less than twice as heavy as aluminum. Corrosion resistance is excellent, tensile strength is high, and the melting point for this metal is 3137 F, higher than most of the commercially available metals of today.

At room temperature, titanium has a crystalline structure similar to that of zinc or cadmium. Above 1615 F, the structure is like that of low temperature iron or of chromium. Nearly all the useful alloying metals have crystalline interatomic distances within plus or minus 15% of the comparable dimensions of the titanium lattice. The high temperature transformation characteristics and the interatomic distance similarity indicate that titanium and titanium-base alloys are destined for considerable investigation and development, and that many interesting and valuable alloying and heat treating characteristics can be obtained.

Considerable data and information on titanium are available; but these must be studied and evaluated before general applications can be made. The purpose of this paper is to review briefly some of the information available, and to indicate applications where titanium or alloys based upon titanium can be useful to the engineer and designer.

Methods of Production

Titanium metal is produced by several different methods. The end product of each process is titanium in powder, sponge or ingot form. Consolidation is achieved by a sheath rolling process or by melting in induction or electric arc furnaces. In the melting process, titanium has certain properties which present problems of considerable magnitude. Its affinity for the refractory materials in which it is melted is a handicap in production. Another difficulty of manufacture is its absorption of oxygen, nitrogen, carbon dioxide and other gases. The latter property, however, can be used to advantage in certain applications. Ingot forms of titanium are readily available, and a few standard rolled structural bars and shapes are being produced.

Three basic methods can be utilized to produce a metallic alloy. The constituents can form a chemical compound, a mixture, or a solution. Or the alloy can result from any combination of these basic forms. At room temperature, the crystalline structure of titanium is such as to favor the formation of alloys containing nitrogen or carbon. The crystalline transformation of titanium at elevated temperatures promotes the inclusion of nitrogen or carbon atoms within the structure of the titanium lattice. Rapid cooling, as by quenching, would serve to retain the carbon or the nitrogen, thus making the alloy heat treatable. Such a procedure is exactly analogous to the heat treatment of steel. The crystalline structure of titanium is favorable to the formation of alloys with elements other than carbon or nitrogen under such conditions as to promote the substitution of the alloying elements, atom for atom, into the crystalline lattice structure of titanium.

Alloys of titanium and carbon, with carbon from 0.015 to 1.46%, have been produced and tested. Carbon decreases the ductility of the alloy, raises tensile strength and yield strength, and increases the hardness. Carbon above 1% results in formation of titanium carbides that can be used to impart or improve properties obtained by heat treatment. Fig 1 is a photomicrograph of annealed commercially pure titanium. The structure is remarkably similar to the pearlitic structure of annealed eutectoid steel.

When heated to 2000 F and quenched in oil at 70 F, the structure becomes basically martensitic, as

shown in Fig 2. The effect of carbon on titanium and the heat treating characteristics are typical of the corresponding effects and procedures on iron-carbon alloys. Moreover, as carbon percentage is increased or as quenching temperature is raised, the resultant hardness increases as it does for iron-carbon alloys. It is entirely reasonable to assume that titanium-carbon alloys will be developed and that these alloys will show heat treating characteristics basically similar to those of iron-carbon alloys. Physical properties should also be affected to a comparable degree.

Nickel, manganese, aluminum and tungsten show promise as excellent alloy additions to titanium. Nickel increases toughness by refinement; manganese improves hot-working toughness during hot rolling; aluminum improves both hot and cold working characteristics; and tungsten provides exceptional increase in tensile strength. As yet, none of the alloys are available commercially because the experimental work has not progressed to the point where sufficient application data are available.

Mechanical Properties

The tensile strength of titanium is equal to that of 75ST aluminum alloy, and compares favorably with that of type 304 stainless steel. Yield strength is 90% of the ultimate, is equal to that for 75ST aluminum, but is nearly twice as great as the yield strength of the type 304 stainless.

When titanium is cold worked, the yield strength increases at a rate proportional to the increase in the tensile strength. When stainless steels are subjected to cold work, the increase in yield strength is much greater proportionally. Thus, cold work has a less embrittling effect on titanium than an equivalent amount of cold work on stainless steels, and the effect of operation at elevated temperatures should be less pronounced on titanium than on these steels. At 1000 F, the stress required to produce a 0.2% offset is, for titanium hot-forged bar, 24,000 psi. For type 304 stainless steel, the stress required to produce an equivalent percentage offset is 14,000 psi. For 5% molybdenum low carbon steel, the corresponding stress value is 10,800 psi. Thus, titanium, at temperatures not in excess of 1000 F, shows better yield strength characteristics than the type 304 stainless steel or the low carbon molybdenum steels.

It should not be assumed, however, that titanium is superior to the higher percentage chromium-nickel steels that have been developed, particularly for high temperature service. Future development of titanium-base alloys, however, should show high temperature characteristics far superior to those of the metal or alloys that are available today. Table I lists some of the comparable physical characteristics and properties of commercially pure (99%) titanium, 75ST aluminum, and type 304 stainless steel.

Corrosion Resistance

Titanium evidences remarkable resistance to many corrosive media. For instance, during a salt-spray test, it was found equal to platinum or Hastalloy C as a highly corrosion resistant material. The same test, on the other hand, showed that monel, 75ST aluminum and 18:8 type 316 stainless steel were appreciably attacked.

Galvanic corrosion characteristics are similar to those of monel, copper, nickel and 18:8 stainless steels. Hence, resistance to galvanic corrosion is equivalent to that of the more noble metals. Tests show that the effects of galvanic attack can be predicted by assigning to titanium a position in the galvanic series equivalent to that assigned to monel and similar alloys. Exposure tests in marine atmospheres in which titanium was coupled to other useful metals and alloys show the titanium to be unaffected and corrosion of the coupled metals to proceed in a manner indicated by their position in the galvanic series.

Table I—Comparative Properties of Titanium, 75ST Aluminum and Type 304 Stainless Steel

	Titanium			Type 304 Stainless Steel	
	Annealed	50% Cold Work	75ST Aluminum	Annealed	30% Cold Work
Ult TS: At Room Temp	80,000	125,000	80,000	87,000	168,000
At 1000 F	34,000	—	Not used	49,000	—
Yd Str, 0.2% Offset: At Room Temp	72,000	110,000	72,000	37,000	140,000
At 1000 F	24,000	—	—	14,000	—
Elong in 2 In.	25%	12%	13%	55%	15%

Table II—Resistance of Titanium to Chemical Corrosion

Reagent	Concentration (% by Wt)	Temp, F	Rating
Acetic Acid (Glacial)	99	Boiling	A
Aqua Regia ($3HCL-1HNO_3$)	—	Room	A
($1HCL-3HNO_3$)	—	Room	A
Chromic Acid	10	Boiling	A
Ferric Chloride	10	Boiling	A
Hydrochloric Acid	10	Room	B
	10	158	C
Nitric Acid	65	Boiling	B
	98	Room	A
Sulfuric Acid	10	Room	B
	10	158	C

Table III—Physical Properties of Hot Forged Titanium Bars at Elevated Temperatures

Property	Test Temperatures, F			
	400	800	1000	—75
Tensile Strength	62,000	47,000	34,000	137,000
Yield Strength (0.2% Offset)	39,000	33,000	24,000	124,000
Elongation (2-In. Gage), %	21	15	23	14
Reduction in Area, %	33	53	60	16

Titanium shows excellent resistance to such corrosive media as glacial acetic acid and aqua regia. This resistance is indicated in Table II, where excellent properties are designated by the letter "A", less satisfactory properties by "B", and unsuitability by "C". Resistance to the corrosive attack of dilute acid solutions is excellent. The corrosive conditions found in citrus fruit processing and canning plants has no visible effect upon the surface of titanium.

In the field of metallic materials for high temperature service, titanium-base alloys are likely to find widespread and useful applications. Below 1200 F, titanium shows good resistance to oxidizing atmospheres. Above 1200 F, the scaling effect of oxidizing atmospheres becomes increasingly severe; and above 1300 F, embrittlement occurs. Physical properties of titanium hot forged bars tested at elevated temperatures are shown in Table III. Creep tests at 600 F show no elongation at a unit stress of 20,000 psi. At a unit stress of 25,000 psi, the rate of creep is negligible—less than 0.00001% per hr.

Present and Future Applications

Titanium has already indicated its worth as a subject for future investigation and development. It has very well-known applications in steelmaking, where it is used as a deoxidizer, as a stabilizer for carbides and nitrides, and to reduce grain size in high chromium heat resistant steels. In aluminum alloys, titanium additions are made to refine the grain structure and to increase strength properties. When used as an addition in steels for enameling purposes, titanium acts to stabilize the carbides and prevent reactions with oxides in the enameling coat, thus eliminating the formation of scabs or blisters.

Titanium, with high corrosion resistance, high proportional limit, and low modulus of elasticity, should find many applications in the making of springs where appreciable expansion at low loads would be desirable. Titanium will most assuredly be tried in marine boiler and boiler feed water systems presently using monel or stainless steel. An important industrial application is likely in the manufacturing of lightweight portable hand or machine tools. A most appropriate use, and one immediately applicable, would be in the fabrication of orthopedic equipment, braces, splints and surgical instruments. It

Fig 1—Annealed structure of commercially pure titanium.

Fig 2—Photomicrograph of titanium quenched in oil from 2012 F.

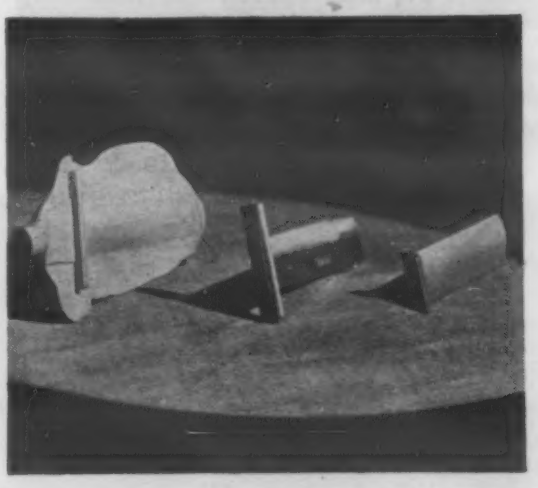


Fig. 3—Small titanium forgings at various stages of manufacture. (Courtesy Titanium Metals Corp. of America)

can also be used to advantage in orthodontia devices.

Numerous applications exist for titanium in the fabrication of military equipment. Its high resistance to salt-water corrosion and its excellent properties when subjected to cathodic attack indicate that titanium will be used extensively in production of ship fittings, marine hardware, and for plumbing and piping installations handling sea water. For shafting material, packing or stuffing boxes, or as a shaft sealing material, titanium should serve very well. In the construction of aircraft, titanium should be used extensively due to its high strength-weight ratios and excellent corrosion resistance.

Rather extensive development and testing programs in industries, schools and military services, involving titanium and titanium-base alloys, are in progress. General applications cannot be recommended at present, but specific applications may be made after consideration of each particular application. Considerable data and information are available, but these must be studied and evaluated before general recommendations are made.

A rather serious difficulty at present is the cost. Commercially pure ingots of titanium cost $5 per lb in 100-lb ingots. The price is $7.50 for quantities less than 100 lb. Thus, it is economically unsound to recommend replacement of steels, copper, aluminum or certain alloys by titanium unless the improvement of physical and chemical properties justifies the additional cost. However, aluminum at one time cost $50 per lb, while today its cost is down as low as 15¢ per lb. Therefore, it is not justifiable to predict that titanium will be handicapped in the future by its cost. Hence, the engineer may expect the development and application of new constructional materials based upon titanium and its alloys which will provide new and better materials for constantly improving processes and techniques.

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Compression Molded Reinforced Plastics Now Finding Industrial Applications

by T. C. DU MOND, Editor, MATERIALS & METHODS

Parts made by a new practical process have good weight-strength ratios, excellent impact properties, and high resistance to heat and exposure.

● THE EARLY DEVELOPMENT of reinforced plastics is credited largely to the military demands of World War II. However, the general class of materials falling within this group has been expanded vastly both as to variety of compositions as well as to ultimate uses. Recent technical advances indicate a much wider application of reinforced plastics, particularly now that methods have been perfected for producing compression molded reinforced plastics parts.

Before discussing a little more fully the latest development, it might be in order to summarize progress which has been made up until now.

Reinforced plastics are those plastic materials which have been strengthened by the addition of fibrous glass and other reinforcing materials such as cotton, hemp, rayon, sisal and paper. Materials of this nature are being used in a number of engineering applications and are serving well as fishing rods, boats, tote boxes and trays, washing machine parts, luggage, aircraft ducts, electrical equipment and many other products.

The progress of glass-reinforced plastics was spurred by needs of the armed forces, which sought some material to protect radar and other electronic equipment from the damaging effects of the weather. The material had to be strong, rigid, impervious to weathering, nonmagnetic and nonconducting (electrically). Because of the last two requirements, metal was eliminated as a possible material.

The one material which came closest to filling all requirements proved to be glass-reinforced plastics. During the last war thousands of radomes were made from the material, and its properties soon earned for it many other important uses. In aircraft structures its favorable strength-weight ratio was important. Similar characteristics made glass-reinforced plastics suitable for body armor for troops.

In addition to the characteristics already enumerated, these unique materials also offered excellent impact resistance, dimensional stability, resistance to attack from exposure or rot, ease of fabrication, and resistance to mild corrosives.

These same properties made reinforced plastics of interest to manufacturers of civilian goods. An example will serve to show how the materials could be applied. One producer of clothes washers designed a circular agitator for its unit that was intended to churn the dirt loose from soiled clothes. The shape of the part was such that there would have been great difficulty in molding or casting the part to shape without excessive cost. The use of glass-reinforced plastics solved the problem and provided an agitator that is performing exceedingly well.

As we again go into a period of defense production, the material is naturally enough finding applications in many other military products. One of these uses is for the cover of the film magazine for a new aerial camera designed in collaboration with the Air Materiel Command, Wright Field, Dayton, Ohio. Glass-reinforced plastic was chosen for this application because of its combination of heat resistance and insulating properties.

The bottom of the film magazine on which the reinforced plastic cover rests contains a heating element which is intended to keep the photographic film from becoming too brittle at the low temperatures encountered at high altitudes. Because film should not be used at temperatures below −5 F and temperatures surrounding the magazine might be as low as −65 F, it becomes the duty of the cover to maintain as much as a 60-deg temperature differential between the inside and the outside of the magazine. An incidental advantage of the plastic material over steel in this application is the saving of about 4 lb per unit in the cover alone.

Compression Molded Parts

One of the most important recent developments in the field of reinforced plastics is the revelation that a practical method has been devised by which such materials can be produced as compression molded parts. One of the first companies to offer such parts is Laminated Products, Inc., which is making complex parts of Fiberglas-reinforced Laminac.

The combination of materials used has earned an enviable reputation for itself in many applications in the electrical and chemical process industries. The material has been produced in the form of sheet stock and as simple molding by Laminated Products under the trade name Glastic. Glastic has good weight-strength ratios, offers high electrical insulating characteristics, and is resistant to

mild acids and solvents. In addition it has good impact resistance.

In making flat sheet stock, mats of glass fibers are placed in position in the forming dies. Next, resin is poured in and the dies closed. As pressure is applied, the resin moves and the mat remains close to its initial position. The same general method is used to produce simple moldings such as shallow trays.

When complex small parts were attempted by similar methods, it was found that the glass mats could not be preplaced in ears, lugs and where compound curves were involved. When pressures were applied, the fibers would not flow into recessed areas. Thus, the cavities filled with resin, resulting in parts that did not have the desired strength and impact resistance.

After considerable investigation and experimental work, a method was perfected which permitted the glass fibers to move with the resin in a fixed ratio to all parts of the die. Details of the process are retained as a trade secret by its developers, but it is said to be capable of producing many kinds and shapes of parts.

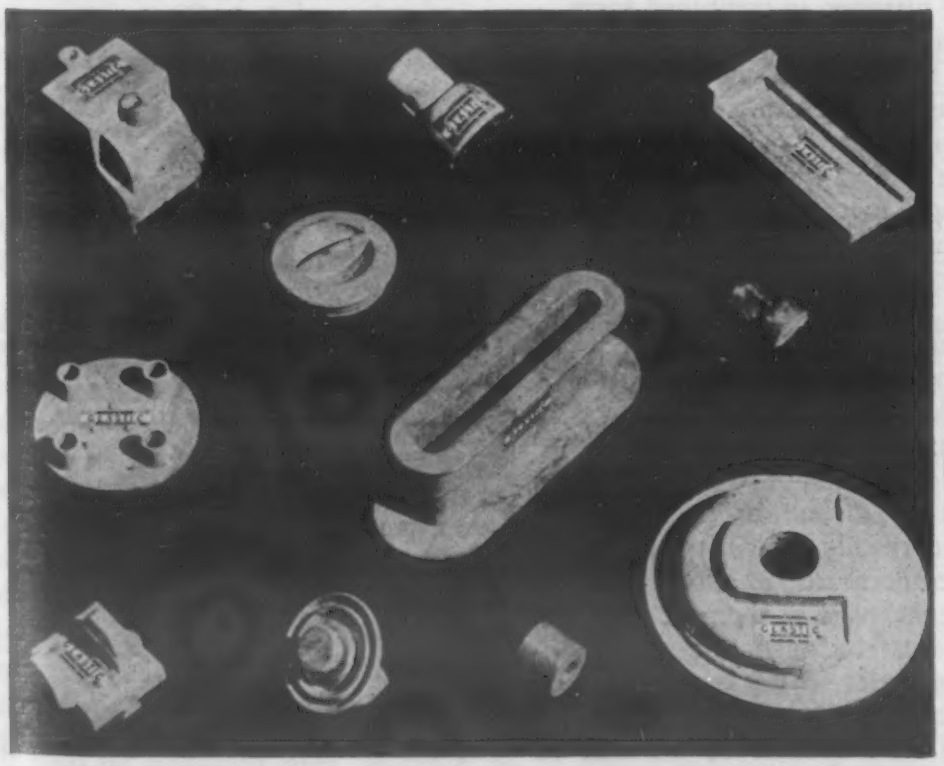
One of the most interesting parts by the compression molding method is an insulator used for supporting the conductor bars of complex overhead materials handling systems. This use takes advantage of the electrical properties of the material as well as its strength and impact resistance. Previously, the part was made of phenolic with two metal inserts for added strength. The use of metal in the insulator offered the possibility of shorting, which, of course, was undesirable.

More than 150,000 insulators have been made and put into service. In addition to passing the standard tests for parts of this nature, a sample part was thrown from a height of 15 ft without damage other than superficial marring.

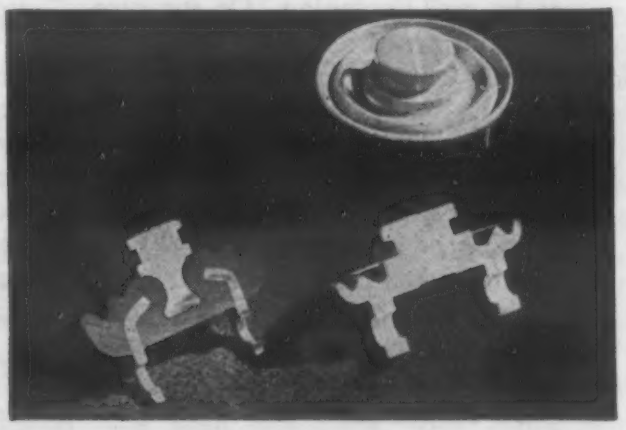
Other parts produced by compression molding include armature brush holders, container closures, field coil bobbins, and many others. In the case of closure, used on a dry ice container, the part was required to serve as a heat insulator and also maintain its strength at dry-ice temperatures.

As a result of the success of these early applications, it seems likely that compression molded reinforced plastics parts will find ready use, particularly now when most of the common metals are in short supply.

The magazine cover on this Ryan aerial camera must maintain its properties over a wide temperature range and insulate strip film from sub-zero temperatures. It is formed from glass-reinforced plastics.



Most shapes that are normally possible with compression molding can be previded in glass-reinforced plastics. Included in this group are armature brush holder studs, closures, insulators and field coil bobbins.



Compression molded glass-reinforced plastics electrical insulators made by Laminated Plastics, Inc., replace similar parts into which were molded metal inserts which provided additional strength. The new insulators (right), in addition to being stronger, provide better electrical properties.

These gas fired rotary furnaces are used for carburizing steel parts. (Courtesy Oxygen City Steel Treating Co.)

Which Process for Case-Hardening Steel

by KENNETH ROSE, Western Editor, Materials & Methods

● THE NEED FOR increased wear resistance or for local strength in many steel parts can be frequently met by case-hardening. Of the case-hardening processes, the most widely used are those that provide for a differential content of hardening elements, such as carbon or nitrogen, and those that involve a differential heating of the metal, such as flame hardening or induction heating. Both have the advantage of producing a piece of work with a hardened surface that resists abrasion or possesses higher strength, while the softer core imparts toughness.

The methods providing for increasing the content of hardening elements at the surface of the steel make sure that the core will remain soft after heat treatment by holding the carbon content of the original material so low that it will not harden when quenched. A simple quench, therefore, will harden the enriched surface and keep the core soft. In addition to the centuries-old process of carburizing, there is the process of cyaniding, in which the case is enriched with both carbon and nitrogen, and the nitriding process, which achieves increased hardness by addition of nitrogen in combined form.

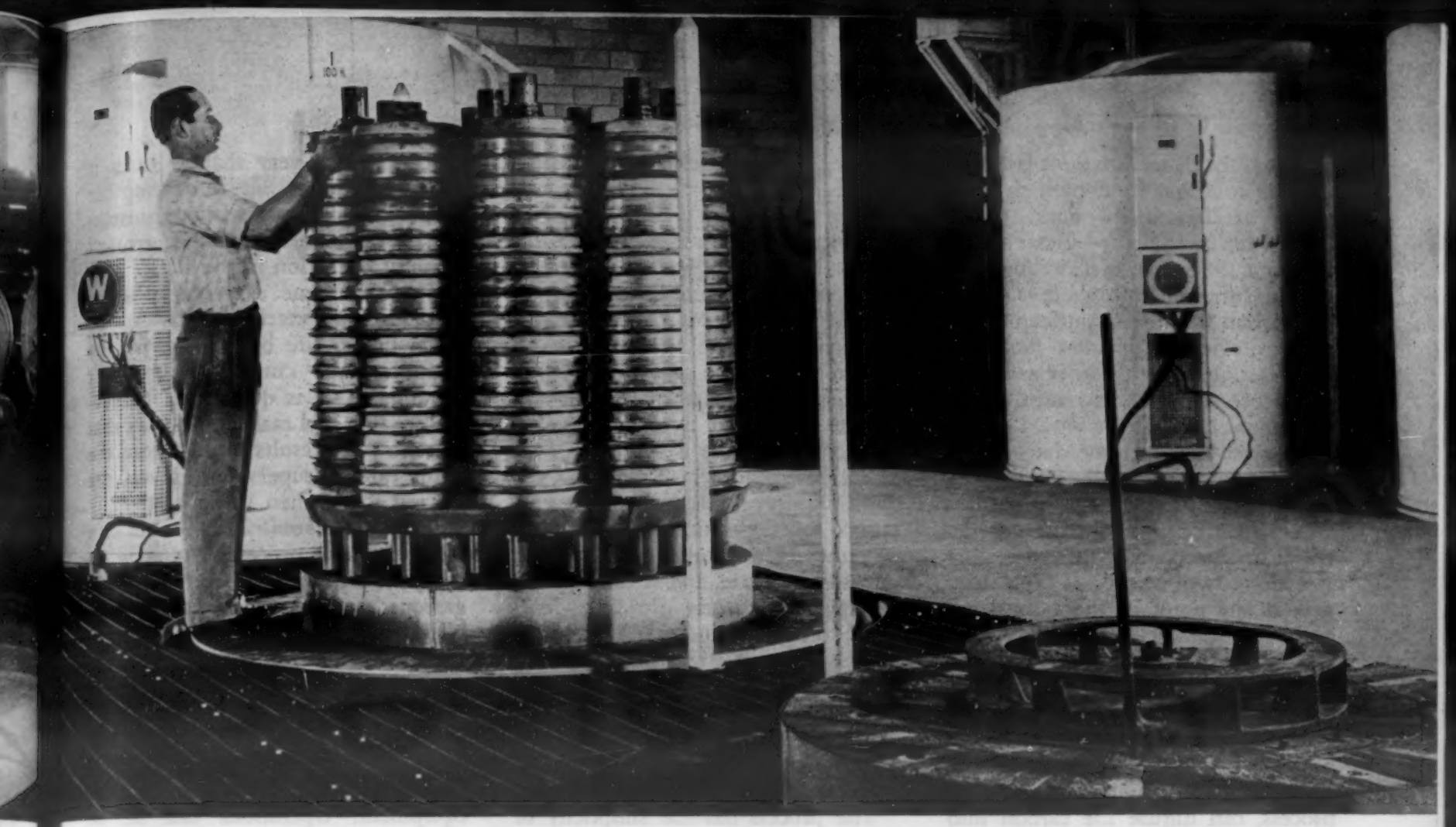
These processes have been elaborated by the use of various media to provide the enriching elements, and by equipment to make the process as flexible in operation as possible. Controls and mechanized handling and conveying can be used in many installations to make operations automatic.

A comparison of the three types of processes, with a general outline of the field of each, might be made as follows:

Carburizing—For all steels low enough in carbon to take up that element readily. Usually performed at a temperature of about 1700 F, making warpage of the part a danger. Work must be quenched to develop full properties in the case. Depth of case can be varied from a few thousandths to a quarter of an inch or more, and carbon content can be controlled throughout the depth of the case. Parts of the surface can be blanked off for differential carburizing.

Nitriding—For special nitriding steels primarily, but some improvement in hardness and wear resistance possible with certain stainless steels and with the engineering steels in general. Long-time heating at about 930 F required, decreasing danger of warpage. Quenching not necessary unless hardness under the case is required to provide additional strength. Case very hard, quite shallow; primarily for wear resistance under severe service. Parts of the surface can be blanked off for differential nitriding.

Carbonitriding—For all carburizing steels. Usually done at about 1550 to 1600 F. Quench required to develop full properties, but superficial hardness can be developed without quenching, reducing the danger of warpage. For shallow cases only. Permits development of some of the hardness of a nitride case by the quicker methods associated with carburizing. Can also be used to increase the hardness of quenched case beyond what would be obtained with straight carburizing, or to develop the same hardness at a slightly lower temperature.



Bell type furnace is being loaded with a charge of internal gears to be nitrided. Bell to cover inner hood and charge can be seen in the rear. (Courtesy Westinghouse Electric Corp.)

—Carburizing, Nitriding or Carbonitriding?

It can be stated at the outset that in all these processes the trend is toward the use of gaseous atmospheres to achieve the type of case desired. This does not mean that the salt bath, or even the older pack carburizing, does not have a place. In all cases, though, the gaseous atmospheres are so much more flexible and easily controlled by automatic or semi-automatic equipment that they have been steadily gaining in favor and in use.

Carburizing

Pack carburizing—Pack carburizing can be done in most plants without any special equipment whatever. Any furnace with the necessary capacity and temperature range can be used for pack carburizing, and the pots can be ordinary sheet iron boxes or cylinders, or even drain tiles. Specially prepared packing compounds will give best results, but many types of carbonaceous material have been used, including wood charcoal, leather scraps, animal charcoal, and various mixtures of these.

The packing of the work can be done by unskilled men, and the remainder of the process likewise requires neither skill nor training.

With pack carburizing, case depth cannot be controlled with the accuracy possible with either the salt bath or the gaseous atmosphere. For this reason pack carburizing is largely confined to work requiring a heavy case—perhaps 0.035 in. or deeper. It is true, however, that pack carburizing has been used for all sorts of carburizing work, and could be so used again if circumstances made it economically feasible. The pack process, unlike the remaining two procedures, is limited to carburizing, and addition of nitrogen is not practicable. Likewise, the diffusion of the added carbon into the metal is not done except in a rough and approximate manner by control of the carburizing compound.

Pack carburizing is relatively inflexible. About the only variables in the processing are the time and temperature of heating in the furnace, and, to some degree, the composition of the carburizing compound. By adding a diluent, such as coke, and by regulating the amount of energizer, usually an alkaline carbonate, some degree of regulation of the case can be obtained, but control of time and temperature of heating remains the only really flexible part of the operation. This makes the process most efficient when the work is well standardized as to depth and type of case. Also, quenching from carburizing heat is impractical. This means that a second hardening heat is necessary to obtain the benefits from the increased carbon content.

Liquid carburizing—Salt bath carburizing is quite flexible. The case depth can be light or heavy, and speed of carburizing can be controlled by regulating the temperature of the bath, or, usually, by the time in the bath. All sorts of work can be carburized and the operations can be readily mechanized. Depth of case and the characteristics of the case can be closely controlled, and duplicated through a long production run.

Salt bath carburizing operates at a high efficiency, with rapid heat transfer from molten salt to work. The molten salt provides an excellent cover for the metal, and adhering salt protects it during the period of transfer from carburizing bath to the quench. However, bath composition can change during operations. Loss of salt due to dragout must be made up by the addition of more salt, and deterioration of the salt itself due to carburizing reaction makes frequent adjustment necessary. Proper control

will prevent these variations from becoming sufficient in amount to cause erratic hardness in the work.

Gaseous carburizing—Gaseous carburizing, in which a carefully controlled furnace atmosphere supplies the carbon for surface enrichment of the steel, has the greatest flexibility in operation. As with other gas treating processes, the ease with which the atmosphere can be varied at any time gives the operator the greatest degree of control of the process. A well-equipped gas carburizing unit will permit a slight increase or decrease in the content of carburizing gas, along with control of the carrier gas, at any point in the carburizing cycle. Most units have their own atmosphere generators, so that the operator can balance the supply of carburizing gas against the decarburizing constituents in the carrier gas, and by reducing the carburizing gas during the later stages of the process, can diffuse the carbon into the steel, controlling both total depth of case and composition of the case throughout its depth. Batch or continuous processing can be done, and operations can be readily mechanized, including the final quench and discharge of the work.

Depth of case and case characteristics can be accurately controlled, and duplicated through a long production run. Controls are simpler with this type than with either liquid or solid media.

The investment for a gas carburizing furnace, complete with atmosphere generator and all controls, will be high, but the cost of processing is probably the lowest of any of the types of carburizing equipment.

Nitriding

Nitriding is not done with either solid or liquid media, though it is possible to produce a high-nitride, low-carbide case in the cyanide bath that bears some resemblance to a nitrided case.

True nitriding, the gaseous process, gives best results only with special steels; steels containing aluminum, and selling at a premium price, are necessary to obtain the typical case characteristics. Other steels, such as the stainless types and many SAE series, are only slightly hardened by nitriding, but show improved wear resistance and fatigue resistance.

The true nitrided case is extremely hard, very shallow, and develops its hardness without quenching. Its special field of application is with fully finished pieces, as even a light grind would remove most of the nitrided surface. It imparts a high degree of wear resistance, and because of the relatively low temperature at which the process is accomplished, and the absence of quenching, the work is distorted very little. It may be necessary to back up the case by hardening the steel by the usual quenching procedure if the part is of heavy cross-section and service is severe.

For best results with nitriding, the work requires rather elaborate preparation. Any decarburized surface must be removed, the metal should be put into sorbitic state, and stresses should be relieved before nitriding. This tends to increase the total cost of the process substantially.

The process is slow and most work will require about 8 hr or longer for development of a nitride case, and furnace treatments of 30 hr are not uncommon.

The process has the simplicity of control typical of gas treatments generally. Such changes as are necessary in the concentration of ammonia during the procedure are easily made in either batch or continuous operations.

Carbonitriding

Carbonitriding, or cyaniding, is still done occasionally with a solid medium, but only as a toolroom or other operation with single pieces. As a production process it is confined to liquid or gaseous media.

Liquid cyaniding—The bath used in cyaniding is poisonous. This is not as important in determining the use of the process as some other factors, but it does mean that special precautions must be taken in the handling of the bath compound and the work, and in removing fumes.

Depth of case can be controlled by the length of time in the bath, and the relative amounts of carbide and nitride formed can be varied slightly by controlling the temperature of the bath. At temperatures in the lower part of the range, near 1500 F, the amount of nitrogen taken up by the steel is larger in relation to the amount of carbides formed.

Handling of the work can be varied or mechanized as with other salt bath installations, and bath temperature and time can be regulated to meet the requirements of the job.

While the case is principally a carburized case, and requires quenching to develop full hardness, the added nitrides increase the hardness somewhat, probably due to increased rate of cooling. In very shallow cases it is sometimes possible to develop file hardness in the case without quenching, thus eliminating the greatest cause of distortion in the work.

There is some evidence to show that machine cutting tools can be given longer life between grinds by cyaniding the cutting edges after grinding. This is questioned by several leading tool makers, who say that the extra life results mostly from the more careful supervision given the cutting tools when under test.

Gaseous carbonitriding—This is a relatively new process, but it is already well established. As with other gaseous methods, it has great flexibility. The atmosphere can be easily varied from one suitable for straight gas carburizing to one producing a case with a high proportion of nitrides. Time in the furnace and temperature of furnace are as readily changed as with any other type of equipment. Operations can be of batch type, or continuous, with automatic controls.

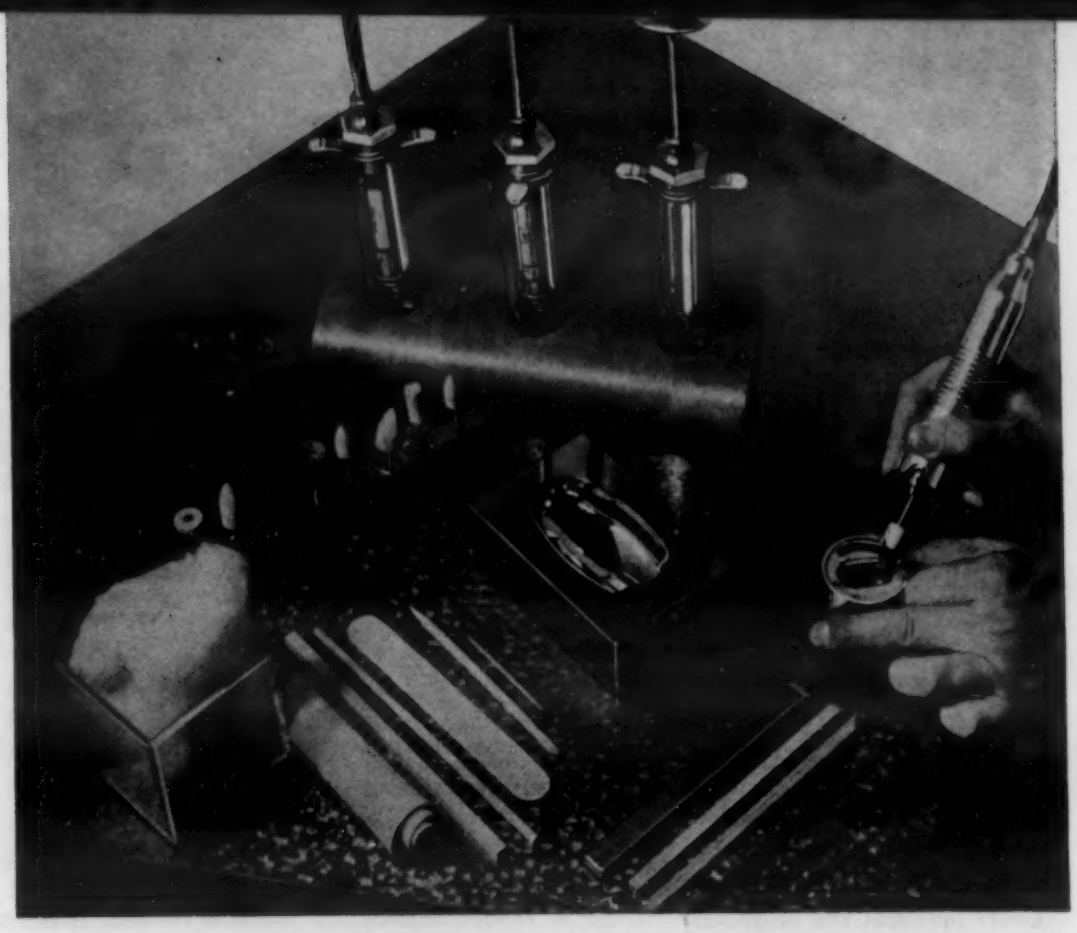
While cyaniding in the salt bath permits some control of case composition, the greater flexibility of the gaseous atmosphere equipment makes it possible to increase the proportion of nitrides to a much greater extent. For most work the atmosphere will contain from 1 to 5% of ammonia to produce a case that will quench out to a higher hardness than could be obtained with the straight carburized case. If superficial file hardness with minimum distortion is desired, the ammonia in the furnace atmosphere may be increased to 10 to 15%, when the case will develop file hardness without quenching.

It is generally agreed that while the original investment is high, the cost of gas carbonitriding is lower than that in other media. This has been the most important factor in its steadily growing use as a mass production case-hardening method in industry.

From these outlines of the features of each of the three case-hardening processes it is clear that each process serves certain needs in industry, and that each medium has particular advantages that will demand its continued use as a supplier of case-hardening elements. Newer processes supplement older methods rather than succeed them, and with improvement of pack carburizing methods and materials that process, the first of the means for enriching the surface of steel continues in industry along with the newer gas atmosphere methods.

Closely graded diamond compounds can save many man-hours in the finishing and polishing of hard molds, dies and tools.

by S. G. KELLEY, JR.
Materials & Methods



Felt bobs being used with diamond abrasives to achieve a high finish on plastics molds. (Courtesy Hyprez Div., Engis Equipment Co.)

Uniform High Quality Finish Obtained with Diamond Powder Abrasives

• DIAMOND POWDERS have traditionally been used as abrasives bonded or charged into wheels or laps. Normally, such powders were mixed with olive oil, pine oil, or similar vegetable oils to produce a paste. This paste, however, was not stable, as diamond particles quickly sank to the bottom. Therefore, loose powders were not considered satisfactory except in industries where they were traditionally employed, such as industrial tools or the processing of diamonds into gems.

The increased use of hardened or chromium-plated steel in the plastic-mold and die casting industries, and the rapidly advancing use of tungsten carbides, created an urgent demand for diamond powders in a permanently mixed form permitting their easy and convenient use, assuring reliable time values, and producing, generally, a better finished piece at greatly reduced cost.

Description

Diamond powders are crushed from bort, an industrial grade of diamond not suitable for gem or tool use. During the war the National Bureau of Standards established grading specifications for diamond powders which were widely accepted in the industry. These standards were recently modified, and the present recommended grading, along with the most important uses of the various grades, is shown in the accompanying table.

Whereas conventional abrasives (the hardest of which are about one-third as hard as the diamond, without its wear resistance) do not require supreme accuracy in grading, this is essential for diamond powders. When properly graded and cleaned, they contain only a small percentage of fine particles, an excess of which would reduce the working efficiency. There will also be no particles present larger than the standard to prevent irregular scratching. If these powders are then put into a vehicle or paste, uniformly and permanently distributed, and if the paste is so designed that it will release the diamond particles properly, the best cutting effect is assured.

The vehicle, or oil-like carrier of the diamond abrasive particles is usually a synthetic developed specially to: (1) keep diamond particles separate and permanently suspended; (2) furnish lubrication while holding the particles on rapidly revolving tools with a minimum of throw-off; (3) obtain a more intimate relation between lap and workpiece and thus assure maximum efficiency in the abrasive cutting action of the diamond. It is usually colored for easy abrasive particle size identity, is packaged in hermetically sealed transparent cartridges, and applied to the work with a syringe type applicator. A thinner is furnished by the compound producer but, in addition, the user can thin with kerosene or other light oil if the consistency of the standard compound is not suitable.

Diamond compounds are supplied in two to four concentrations (diamond content in relation to total weight) for most of the standard grades of diamond powders. Generally the harder the material to be finished, the higher the concentration should be. It is important that this concentration should be low on soft materials not only to save cost but also to ensure the best finish.

Diamond abrasive compounds are ordinarily not recovered, because of the small amount of material needed to refine the surface of the workpiece effectively. In a few cases the

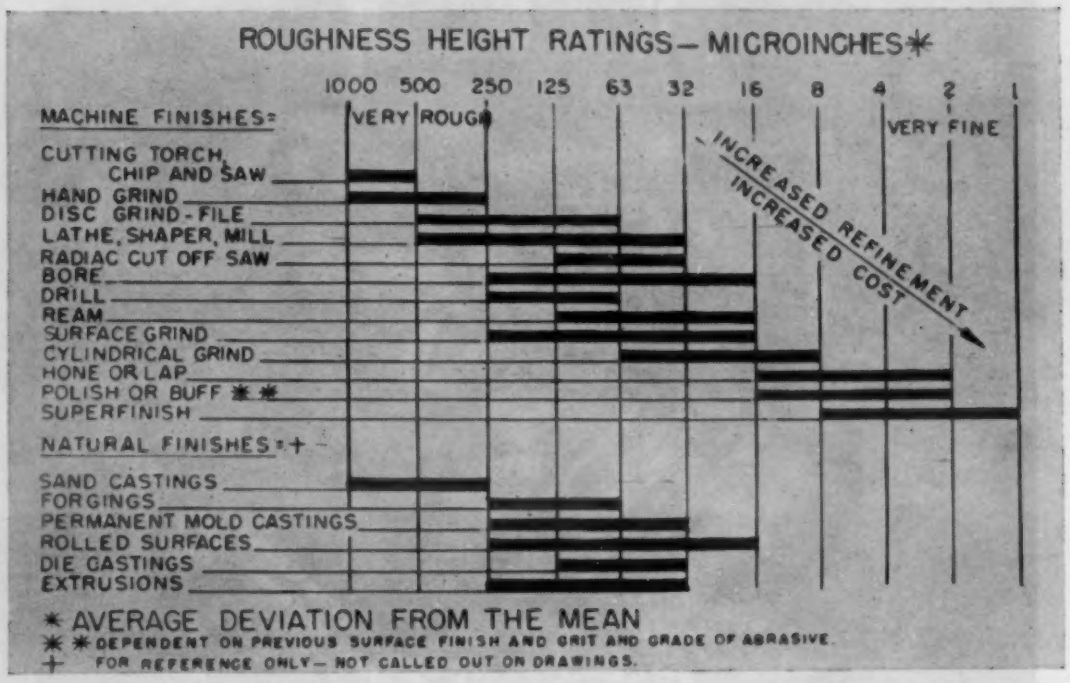
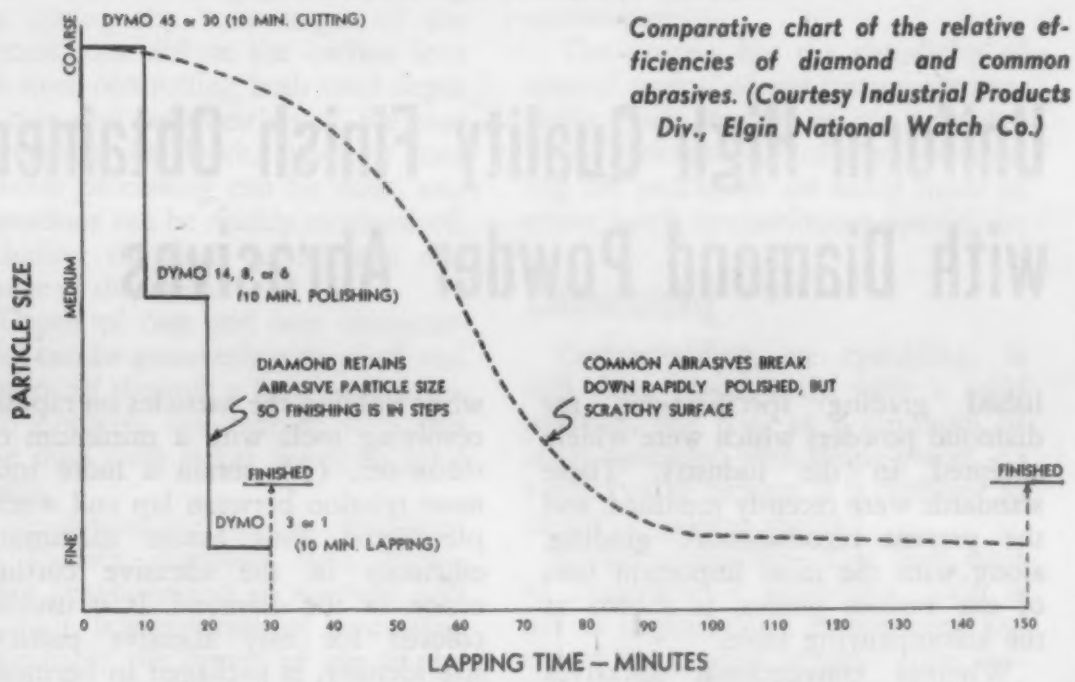


Chart indicates the roughness inherent in various natural and machine finishes. (Courtesy Industrial Products Div., Elgin National Watch Co.)



Comparative chart of the relative efficiencies of diamond and common abrasives. (Courtesy Industrial Products Div., Elgin National Watch Co.)

Grades and Uses of Diamond Powder Abrasives

B. of S. Grade	Equivalent Mesh Size	Particle Size (Microns)	Principal Uses
¼	60,000	0-½	For polishing metallographic specimens and for finest polish.
1	14,000	0-2	For final polishing of molds for clear plastics and similar applications.
3	8,000	1-5	For final polishing on carbide dies, hard chromium-plated tools, plastic dies.
6	3,000	4-8	For general finishing, intermediate polishing on drawing dies.
9	1,800	6-12	For general intermediate polishing.
15	1,200	8-22	For preliminary polishing, especially for carbide tools. Work taken from a diamond wheel can be polished in one step.
30	600	20-40	For finishing of steel or carbides without polish.
45	325	30-60	For removing stock preparatory to polishing.
60	230	35-85	For substantial stock removal—usually first step.
230 mesh	230-325	—	For rough stock removal preparatory to finishing.
170 mesh	170-230	—	For preliminary sizing.
100 mesh	100-120	—	For hogging.

abrasive can be washed out of the lap with kerosene and recovered.

Applications

Broadly, diamond compounds, with their closely graded, very hard particles are used for two main purposes: (1) to produce a uniform finish, and (2) to polish very hard materials.

Among those applications requiring a uniform finish, diamond compounds are used on: plastic molds for rapid stock removal and final, mirror finishing; rubber molds to produce a uniform finish which will give the rubber part an attractive finish; and die casting dies, in which a high finish is utilized to eliminate further finishing of the parts manufactured.

Tungsten carbide dies and tools, because of their hardness, require the diamond compounds for finishing operations following grinding with "green wheels" or diamond wheels. Metal forming tools are polished to ensure proper form and extended die life through proper die contour and low die friction.

Fuel injection parts, gages, tools and similar parts requiring hand operations as well as machine lapping are generally finished more effectively, and in reduced working time, with diamond abrasives.

Metallographic specimens, it has been found, can be given a high polish irrespective of hardness. This is because the sharp cutting action of the diamond will greatly reduce polishing time, thereby maintaining contrast.

How Diamond Abrasives Are Used

As general practice it may be well to finish a piece to within a few thousandths of final size by conventional methods, such as diamond wheels in the case of tungsten carbides, grinding or stoning with steel. Thereafter the piece can be lapped with a relatively coarse grade of diamond powder or compound—generally grade 45 or grade 60. This will produce a uniform matte finish which can then be prepolished with compound 30 or 15; final polish is usually achieved with grade 3 or 6—in extreme cases, grade 1 or ¼ can be applied.

The compound is applied by means of a lap which may be metallic or nonmetallic, machine driven or hand held. In general, hard laps are used for stock removal while flexible laps of increasingly soft materials are

used to produce increasingly high polishes.

When perfect flatness is required, relatively hard laps are recommended for the entire finishing process. For final polishing, a thin sheet of paper can be placed on the lap.

Lapping Materials

If soft steels or soft metals have to be lapped, diamond powders can be retained in the work piece if substantial pressure is used at slow speeds. Therefore, soft materials should generally be polished only with soft tools or lapped with medium hard laps at relatively fast speeds and low pressures.

Of the metallic laps, cast iron and soft steel are the hardest. Cast iron holds the abrasive better than steel because of its surface porosity, and is mostly used for large flat laps. Its rigidity makes it the best type of lap when flatness or parallelism must be maintained in the workpiece. Steel is most used in the form of small preshaped pieces such as pins to prepare the entrance angle of carbide drawing dies.

Copper makes an excellent lap. It is softer than steel or cast iron and takes a better charge of powder. Other factors being equal, finer cutting can be done with the copper lap. It has an additional advantage in its ability to have diamond powders in loose or compound form charged into the body of the lap which will then retain the valuable abrasive longer.

Lead is usually used as an alloy with either tin or antimony to give it greater hardness. The lead alloy laps are softer than copper, and are used to obtain a smoother finish. They are not, however, recommended when flatness or dimensions must be held closely.

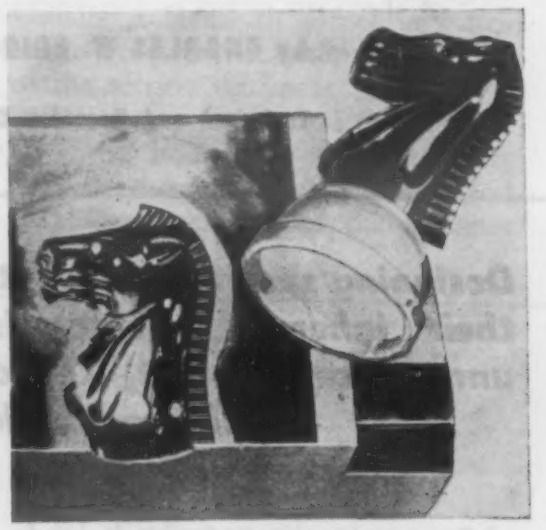
Of the nonmetallic laps, the hardest are the laminated phenolics. Canvas laminates give the roughest cuts, linen next, and the paper-base laminates the finest. All are used where a medium polish is desired, and a small amount of stock is to be removed in obtaining it. Wood laps can be of maple or boxwood for harder requirements, or of pitch-free white pine or hard grades of balsa for softer types. Balsa is frequently used in stock form for the final polishing of carbide drawing dies, as the stick will crush to the shape of the interior die surface. All the woods are used for final polishing with the finer grades of diamond abrasive, such as No. 6 or No. 3. The harder woods are more frequently used as rotating laps for machine lapping and the softer kinds, pine and balsa, find their greatest use in hand lapping.

Felt laps are supplied in a range of hardnesses from Spanish hard to the soft cloths. The harder grades can be shaped and used for machine lapping. Felt bobs are used with rotary tools much as are the balsa sticks in hand lapping. Felt laps will bring out a very fine polish, but care must be used in employing them to avoid development of "orange peel", an irregular wavy surface, or "fish tails", a defect caused by gouging out a metallic grain and digging a tiny, shallowing furrow along the work surface with it. Stainless steel is especially susceptible to these blemishes. In all cases it is recommended that surfaces be finished with coarser grades until they show a uniform, straight and dull surface from proper hand or machine lapping. Polishing should only start after surface defects have been removed.

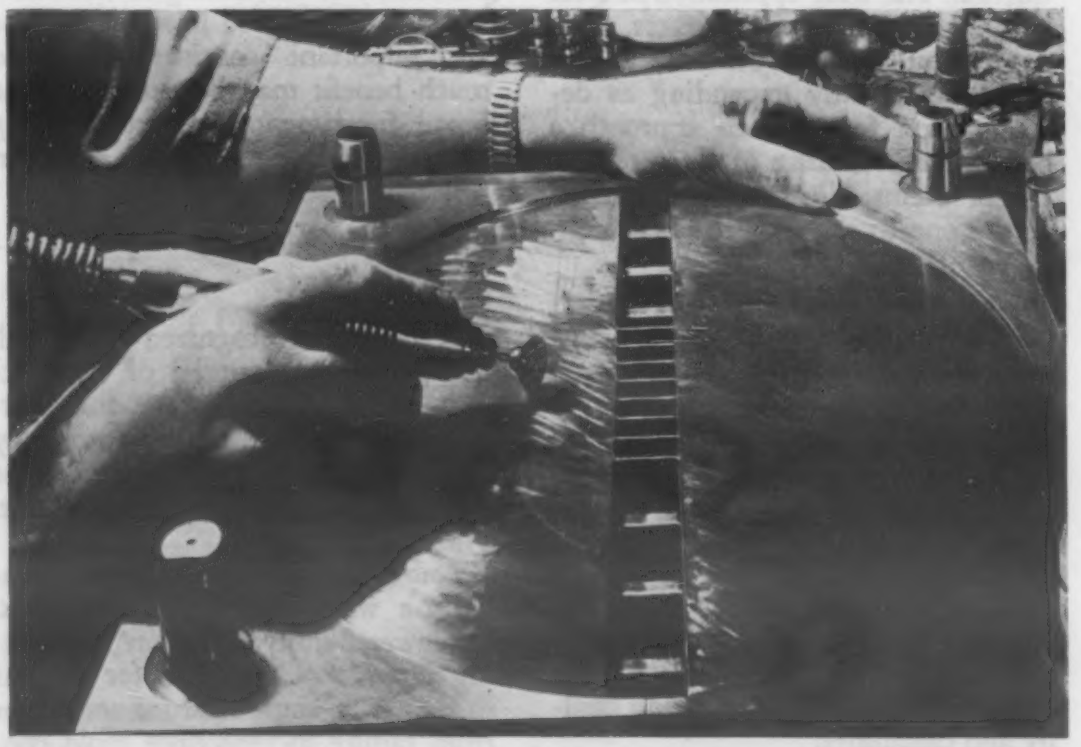
Loose cotton, the softest of the lapping materials, can be hand held or wrapped on a stick, or felt bob. It is used with only the finest powders for obtaining the highest luster on the work.

Another method of applying diamond compounds is to use a brush with nonmetallic bristles, such as the tampico brush. This is useful for intermediate steps between lapping and polishing; it will round off sharp corners and prepolish parts of the surface which cannot be well reached with laps. Brushes are sometimes used in a large revolving wooden lap for polishing large flat surfaces, but cannot be expected to maintain flatness as would a harder lap.

Molded plastics parts illustrating the necessity for high finishes on molds. (Courtesy Hyprez Div., Engis Equipment Co.)



Mold and corresponding piece show transfer of high finish from mold to piece. (Courtesy Hyprez Div., Engis Equipment Co.)



Polishing a mold using a diamond compound and brush. (Courtesy Industrial Products Div., Elgin National Watch Co.)

Good Steel Casting Design Improves Quality and Reduces Costs

by **CHARLES W. BRIGGS,**

Technical and Research Director, Steel Founders' Society of America

Designing specifically for steel castings, keeping in mind their inherent characteristics, will often eliminate unnecessary weight, reduce cost of production, and better service properties.

● CORRECT STEEL CASTING design is of paramount importance as it is responsible for satisfactory casting service and economical casting production. The wide application of steel castings in industry indicates their dependability. Their field of application is constantly expanding as designers and foundrymen approach a better understanding of their respective problems, adjusting the objectives of the one to the facilities and technique of the other.

It is not essential that the foundryman be qualified as a designer, nor that the engineer be thoroughly versed in foundry practice. Their common interest is the economical production of a casting which will embody the characteristics of quality and utility. Wholehearted cooperation will result in the avoidance of high production costs. Consultation between the design engineer and the foundry engineer, while the design is in process of development, will improve casting quality and castability.

Too frequently a steel casting design is developed with little consideration of possible changes which might reduce the cost of production or eliminate unnecessary weight, or of modifications which would improve the ability of the casting to withstand the stresses imposed in service. These are important considerations, and much benefit may be derived if the broad fundamentals of steel casting design are understood by the engineer.

Inherent Characteristics of Steel Castings

It must be recognized that steel, like any other material of construction, has certain inherent characteristics which must be understood by the engineer so that he can allow for them in the design of his structure. These are:

Low Fluidity—Liquid steel, in comparison with other common metals, has lower fluidity; therefore, the casting design should not call for sections so thin as to cause misruns and losses from failure to reproduce mold contours or to greatly increase manufacturing costs by requiring use of excessively high pouring temperatures. Sometimes when mold passages are too long and thin they are not completely filled with molten metal and thus are the cause of misruns.

Low Strength at 2700 F—Steel, in common with other metals, possesses very low strength and ductility at temperatures immediately below the solidification temperature; hence, careful attention must be given to design features from the standpoint of reducing possible stresses acting upon the castings at this time.

High Shrinkage—The volumetric contraction that takes place when steel transforms from the liquid to the solid state is comparatively high. This means that much thought must be given to the mechanism of casting solidification so that the contraction is compensated for by a supply of liquid steel.

The lack of sufficient metal to take care of volumetric contraction at the time of solidification of the casting causes shrinkage cavities. They occur in sections which, owing to design, must be fed through thinner sections. The thinner sections solidify too quickly to be of adequate feeding value for the thicker sections. Risers are only effective within certain limits.

The casting design may be such that it is impossible to feed isolated sections of increased mass. For example, section A in Fig 1 would have a shrinkage cavity at the position shown if the section were not fed by a superimposed riser, as shown in B. The manner in which the casting solidifies is shown by the isotherms in the casting and riser. The boss located in the lower part of casting C will contain a shrinkage cavity as the riser will not feed a heavy section through a lighter section in the normally constructed sand molds.

High Cooling Stresses—A steel casting section solidifies from the mold-metal interface toward the center of the section, with the total volumetric contraction occurring at the last point of solidification. The rate of solidification is roughly similar regardless of the section thickness. Thus, heavier sections take longer to solidify than lighter sections. Thinner sections which are integrally connected to heavier sections will completely solidify and start contracting while heavier sections are still solidifying. The temperature gradients so established will result in different rates of contraction, in the different sections after they become solid, thus producing internal stresses in the casting. These stresses concentrate at the

weakest section, which is the hottest section. Such positions are known as "hot spots."

Hot spots may be directly responsible for (a) shrinkage cavities already described, or (b) cracking (hot tearing). Hot tears result where excessive internal stresses resulting from restricted contraction cause members to crack. Abrupt changes in section and sharp angles contribute to the centralization and concentration of stresses and become the location of hot tears.

Preventing Hot Spots

Hot spots are of great trouble in manufacturing steel castings. Anything the designer can do to eliminate them will aid in the production of higher quality castings.

A simple illustration will suffice to acquaint the designer with the seriousness of this problem and the possible remedy. The "L" section shown in Fig 2 is used considerably in practically all castings. If the two arms of the "L" were of the same thickness it may be seen, by the method of inscribed circles, that where the arms join a hot spot will be located. If this hot spot S_2 can only be fed through the arms, when the casting has solidified there will be a cavity somewhere near the center of the inscribed circle, S_2.

If, however, the "L" section were in a location where the junction could be fed directly by an outside reservoir, attached to the casting at the position of circle S_2 instead of attempting to feed through the arms, then the section at S_2 would be sound. Unfortunately, the designer has no way of knowing whether or not the joining section will be fed with an external riser; therefore, he must design the joining member with the thought that the hot spot cannot be eliminated or controlled except through design.

Fig 2 indicates that use can be made of inscribed circles to determine the size of the hot spot or the importance of mass effect. The relation of the mass of metal in two different places in the same section is equal to the ratio of the surfaces of the corresponding inscribed circles (ratio of the square of the radius) that can be drawn in the sections.

The problem of shrinkage cavities at hot spots has been the subject of extensive research, and results showed that the increase in the surfaces of the defects is proportional to the increase of the hot spots. The method of inscribed circles, therefore, is most effective for design use. The designer may easily evaluate with sufficient approximation, by a graphic method, the effect that increased mass or a designed hot spot may have on casting quality.

Strength Considerations

A structure is designed based on its probable service conditions. The structure must possess mechanical strength corresponding to the stresses found in service. The general shape of the structure and the type of the material to be used is determined by the service stress systems to which the structure is to be subjected. The strength of the part will be a function of the thickness of the part. The availability, adaptability and dependability of the material will also be a factor in the selection of the type of material to be used.

The high tensile strength values of steel, as well as its availability and excellent dependability, have made steel one of the foremost materials of construction. Because steel has such high strength values, it is possible to use a thinner section in comparison to other materials.

The high modulus of elasticity of steel assures a casting of rigidity and resistance to deformation under tension and bending strains. The properties of steel are well known; however, detailed information as to the effect of composition and heat treatments on the properties of cast steel is given in Chapters VIII to XI of the "Steel Castings Handbook," published by the Steel Founders' Society of America.

Factors of Safety—The tensile strength or the yield strength of a material is normally the basis of design calculations. Consideration of the strength of the material and the service stresses will establish the thickness of the material. It is seldom, if ever, that the section thickness value so determined will be the one employed. Usually a factor of safety is introduced which will result in the increase of the section thickness.

The safety factor will depend on: (1) the knowledge that engineers have of the service application, and (2) the experience of the designer

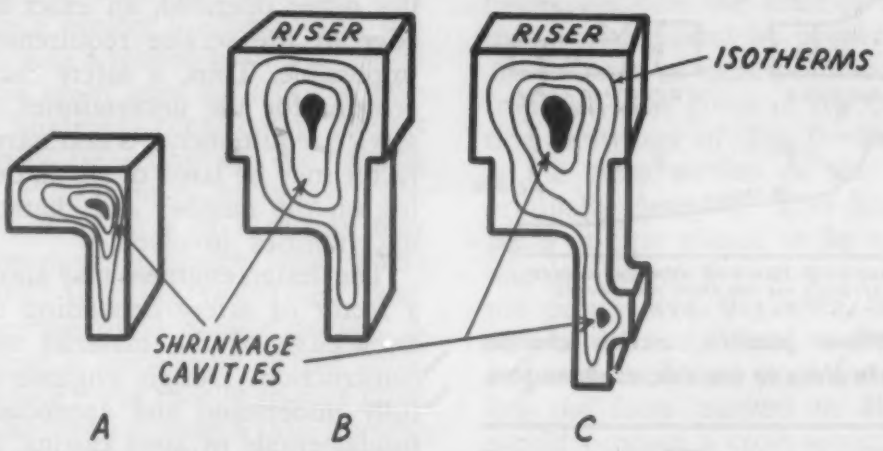


Fig 1—Formation of shrinkage cavities.

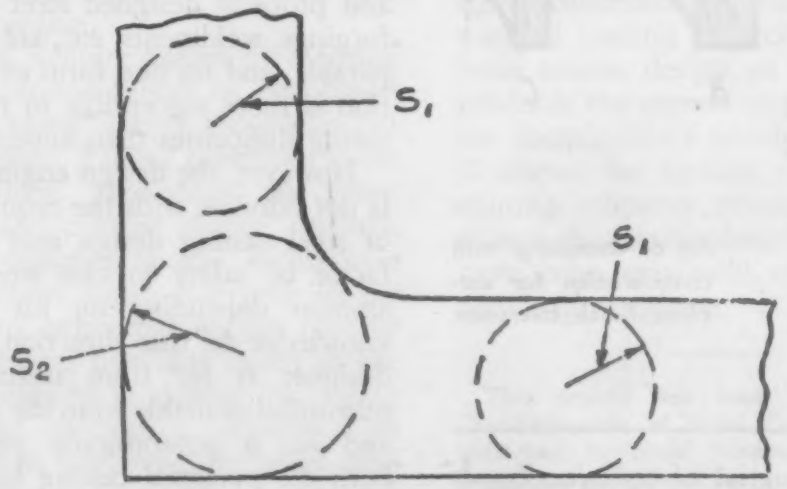


Fig 2—Position of hot spot, S_2, can be determined by using inscribed circle method.

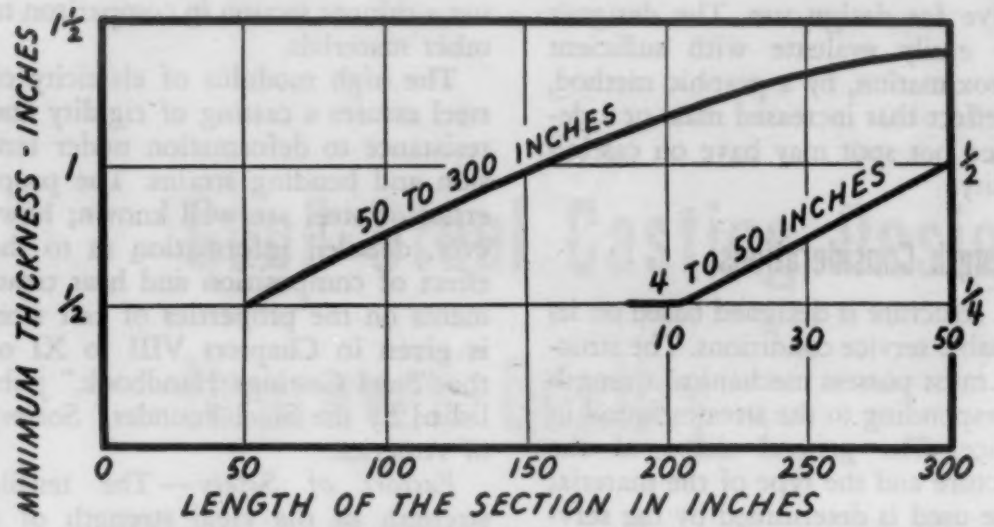


Fig 3—Minimum thickness of cast steel sections is a function of their largest dimension. The curves represent the best design conditions where molten steel enters at one position on the casting and must run the lengths prescribed on the chart. Special techniques permit running of thinner sections than shown.

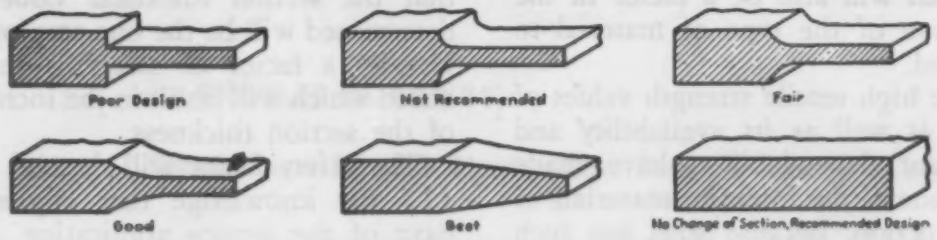


Fig. 4—Acceptable and unacceptable methods of designing section changes.

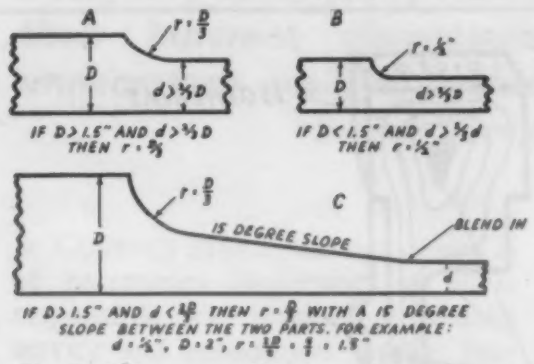


Fig 5—Where possible, section changes should take place on one side, as shown here.

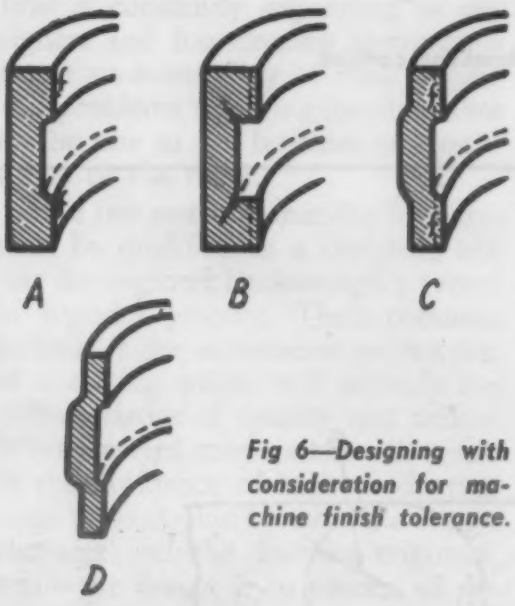


Fig 6—Designing with consideration for machine finish tolerance.

with the material of construction. It is most difficult to determine the service stress and strains of an operating system and, for a new system that has never operated, an exact knowledge of the service requirements is impossible. Thus, a safety factor to account for the uncertainties of the service requirements is necessary. This factor may be large or small, depending on the number and character of uncertainties involved.

The design engineer may also adopt a factor of safety depending on his knowledge of the material used in construction. Design engineers who fully understand and appreciate the fundamentals of steel casting design and who are continually designing steel casting structures do not apply a higher factor of safety for cast steel than they would for other forms of steel structure. After all, steel is steel, and properly designed steel castings, forgings, weldments, etc., are all comparable, and no one form of fabrication is more susceptible to manufacturing difficulties than another.

However, the design engineer who is not familiar with the requirements of steel casting design may apply a factor of safety to cast steel in an amount depending on his lack of knowledge in that direction. Such a designer is far from utilizing the maximum available from the material, and he is economically penalizing both the potential casting buyer and the casting producer.

Factors of safety for (1) uncertainties of service conditions and (2) uncertainties owing to inexperience with the material may vary from 3 to 10, based on the yield strength of the steel.

Section Thickness

Minimum Section Thickness—The rigidity of a section often governs the minimum thickness to which a section can be designed. There are cases, however, when a very thin section will suffice, depending on strength and rigidity calculations.

The fluidity of steel in comparison with other metals is known to be of a lesser value. In order that sections be completely run, it is necessary that a minimum value of section thickness be adopted.

Metal cools as it runs in a section through a mold; thus, a thin section close to the gate which delivers the hot metal will run whereas the same thin section at a distance from the gate may not run. Since the design engineer has no knowledge of the location of the gate, a minimum thickness of ¼ in. is suggested for design use.

It should be pointed out that steel flows best for a given thickness in a narrow, rather than in a wide web. If the ¼-in. thick section is longer than 12 in., then the minimum thickness should be increased in accordance with the values of Fig 3. The curve of this chart represents the best of design conditions wherein molten steel enters at one position on the casting and must run the lengths prescribed on the chart. It must be realized by the designer that provisions may be made by the foundryman through the application of special techniques to pour even longer members through thinner sections than indicated by the graph. However, the applications of special techniques are usually responsible for increased costs of production.

Changes in Section Size—An attempt should be made by the design engineer to design all sections in a steel casting with a uniform thickness. This rule, if followed, reduces the presence of hot spots in a casting to a minimum.

There are times when the designer has no alternative and changes must be made in section size. The examples given in Fig 4 indicate the accepted manner for reducing or increasing a section. Sharp corners and small radii in a change of section are to be avoided whenever possible because of the possibility of internal hot tears at

Table 1—Dimensional Tolerances for Steel Castings That Are Not to Be Machined

Tolerance	Smaller than 12 in.	Between 12 and 36 in.	Between 36 and 120 in.
Average	0.06 + 0.006D 1/16 in. min	0.06 + 0.006D	0.08 + 0.006D
Concise	0.04 + 0.005D 1/16 in. min	0.05 + 0.005D	0.07 + 0.005D
Minimum	0.03 + 0.004D 1/16 in. min	0.04 + 0.004D	0.06 + 0.004D

Where D = longest dimension of the casting in inches

the junction. Large radii or a tapered junction are the best methods of design. Consult with the foundryman to see if sharp corners can be eliminated in most designs.

If it is at all possible, another way of tackling the problem of section change is to make the change take place entirely on one side, as is shown in Fig 5. Again, the change of section size must be progressive and gradual in order to avoid positions of stress concentration. This can only be accomplished by employing a taper if the thin member is less than two-thirds the thickness of the thick member. The values given in Fig 5 are recommended for design use.

Dimensional Tolerances

Steel contracts in volume as it cools from the solidifying temperature to room temperature. This contraction is spoken of as patternmaker's shrinkage, and it is discussed in detail in Chapter XII of the "Steel Castings Handbook." It is suggested that the reader review this chapter so that he will understand the effect that mold and casting resistance has on hindering the contraction of steel castings. These items are closely aligned with dimensional tolerances and must be understood in order to appreciate the limitations that should be placed on any table devoted to dimensional tolerances. However, studies on free and hindered contraction have assisted steel foundrymen in setting up practical values which can act as guides to engineers concerning those tolerances that may be expected on rough steel castings. The tolerance values have been based on the longest dimension of the casting. It is realized that length is not the controlling factor, but nevertheless, the use of the largest dimension is a convenient value for ready use to the engineer.

If the engineer will remember that the tolerance may vary depending on the type of hindered contraction encountered, then Table 1 on dimensional tolerances will be useful to him.

It is suggested that the average value be employed, and in no case should a value of below the minimum value be used. The concise value is one which could be employed on casting designs that have been made by the foundry and, because of their experience with this particular casting design, a concise value can be met and maintained.

Machine Finish Tolerances — The tolerance to be added to the casting section for machining purposes will depend entirely on the design of the casting. For example, a ring gear may require a greater machine finish tolerance than a spoked gear. The reason for this again goes back to the possible hindered contraction stresses that may be acting on the casting while it cools to room temperature. Also, certain faces of a casting may require more tolerance than others primarily resulting from their position in the mold during casting. A face that is uppermost in the mold (cope face) will usually require more machine finish tolerance than the bottom or drag face. The reason for this is that because of design faults or other reasons, loose sand is sometimes encountered in the pouring of the mold, and when this happens it floats upward and lodges in the cope face of the casting.

Again, definite values of machine finish tolerance cannot be established for all casting designs, but guides can be suggested. Table 2 presents a guide to machine allowances on gears, wheels and circular shaped castings.

The designer should incorporate the machine finish tolerance in his design in order that he can observe the problems that may result to the foundryman by producing the casting with the machining allowance in place. It is suggested, therefore, that the designer construct a number of cross section drawings incorporating

Table 2—A Guide to Machine Finish Tolerances

Casting Diameter, In.	Machine Allowance on Outside Radius, In. Rings Spoked Wheels Spoked Gears Circular Shaped Castings
Up to 18	¼
18 to 36	5/16
36 to 48	⅜
48 to 72	½
72 to 108	⅝
108 and up	¾
Bores	
Bore Diameter, In.	**Machine Allowance on Bore Radius, In.**
Up to 1	Cast solid
2 to 7	¼
7 to 12	⅜
12 to 20	½

the machine tolerance so that he may better visualize the contour requirements necessitated by proper design. An example of these points and their importance is given in the cross-section drawings of Fig 6—Sketch A is the cross section of the part as originally designed. The design appears at first glance to be a correct one in that section changes are not too pronounced. However, the addition of the extra metal to the section to permit sufficient stock for machining the faces marked in Sketch A would produce a cross-section shown in B.

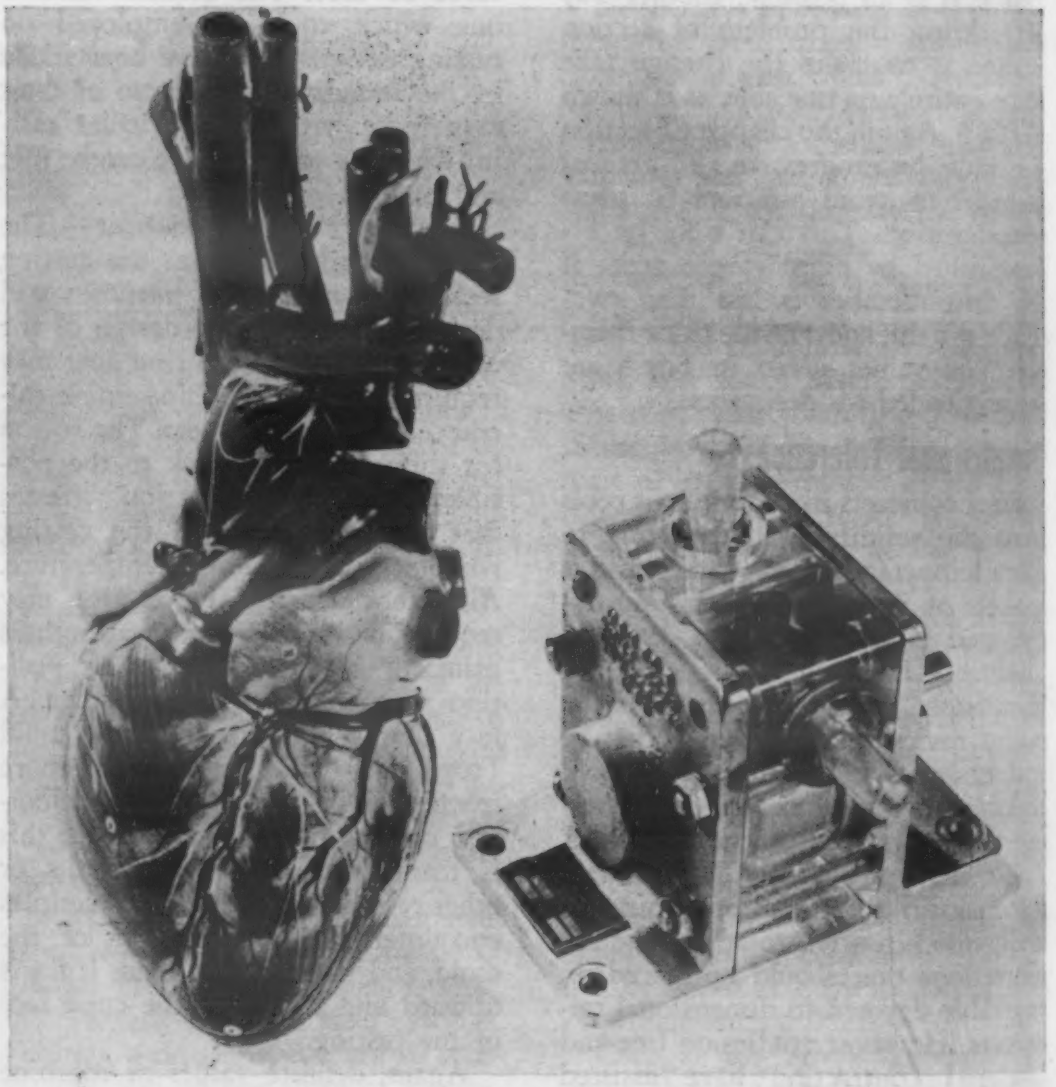
The section variations of Sketch B are many and may make feeding difficult. Also, cracking from the corners is a distinct possibility because of stress concentration resulting from unequal cooling of sections. A uniform section design, as shown in C, produces the correct conditions from the foundryman's standpoint. Sketch D shows the section with the machining tolerance removed, and indicates the section design that should have been originally considered by the design engineer.

This article has been adapted from "Fundamentals of Steel Casting Design", published by Steel Founders' Society of America, and from related information treated in detail in Chapter IV of the "Steel Castings Handbook."

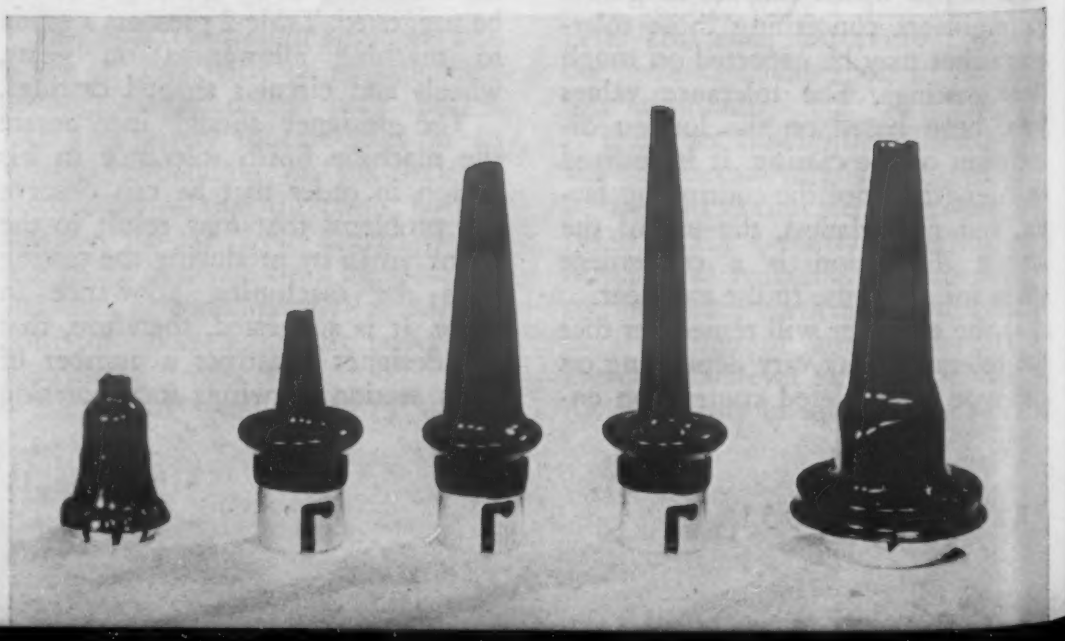
Materials at Work

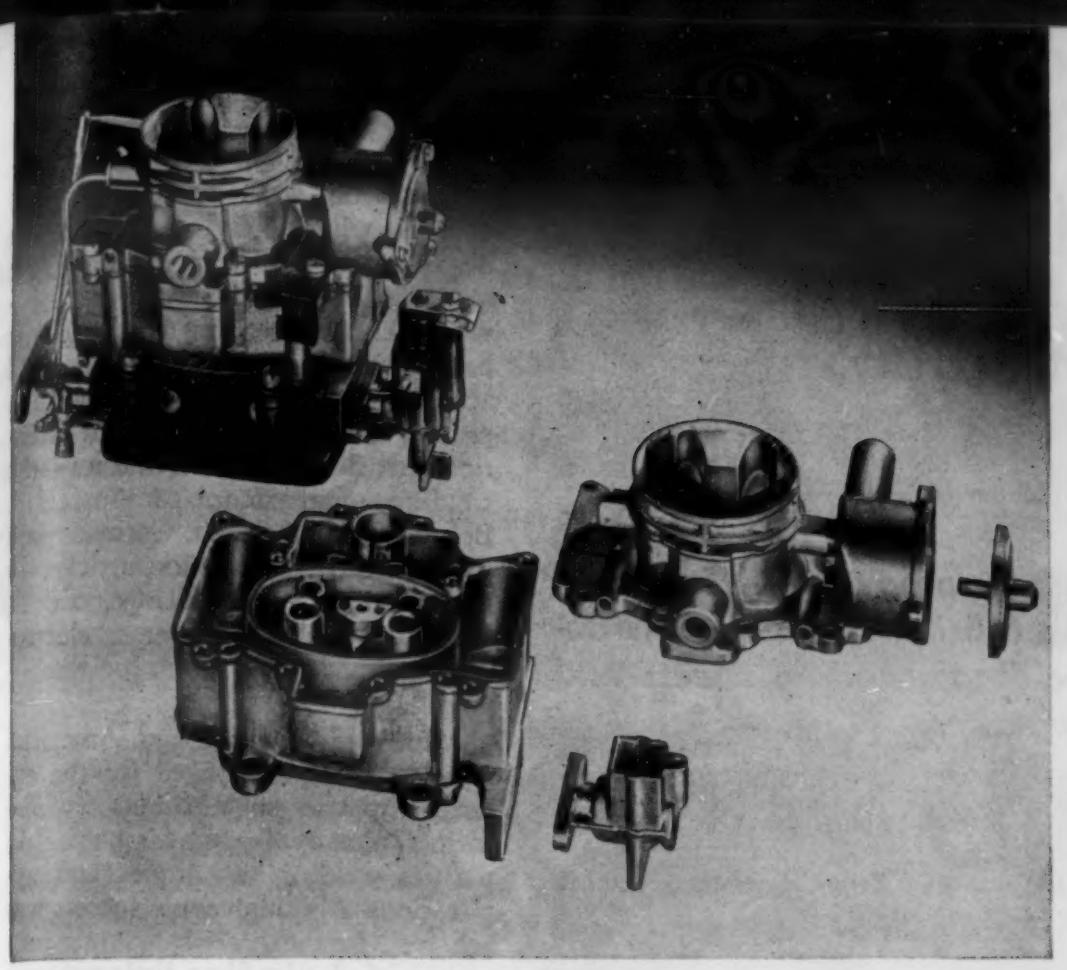
Here is materials engineering in action . . .
New materials in their intended uses . . .
Older, basic materials in new applications . . .

Artificial Heart ***An actual size plastic model of the human heart is shown next to the Vanton Flex-i-liner Pump, which is used in a revolutionary heart-lung device that may restore life to persons "clinically dead" by performing the functions of the heart and lungs. Also used in pumping operations of many industrial plants, the Vanton pump has no stuffing boxes, gaskets or valves, and requires no lubrication. Pumps are available with body blocks of Bakelite, polyethylene or plexiglass, while the internal Flex-i-liner can be made of natural rubber, neoprene, buna, hycar, vinyl, polyethylene or compar—depending upon the chemical resistance required for the fluid or gas to be pumped.***



Vinyl-Dipped Sockets ***Each one of these electrical sockets has been coated with vinyl plastisol by the Watts Electric and Manufacturing Co., of Birmingham, Mich., to prevent the penetration of moisture and dust through the socket assembly into the lamp. The protective coating, based on Geon paste resin, not only saves production time and costs, but provides a better seal than the boots, gaskets and grommets previously used.***





Zinc Die Cast Carburetor *Four zinc die cast parts comprise this complex carburetor assembly, one of Bendix Aviation Corp.'s latest designs. The zinc die castings provide close tolerances necessary for the efficient operation of the carburetor, and require no expensive machining operations.*

Midget Thermostat *An ordinary paper clip is longer than this midget thermostat, manufactured by The George Ulanet Co., Newark, N. J. Weighing less than 1/10 oz, the thermostat can be adjusted to activate relays at any temperature from -70 to 400 F and is precise to plus or minus one degree F. An Inconel spring is used in conjunction with a bi-metallic strip to insure constant calibration over the entire temperature range.*

Electronic Tube Base *This intricate, injection-molded tube base, measuring slightly more than 2 in. in dia and nearly ¾ in. deep, has been developed by Eitel-McCullough, Inc., San Bruno, Calif., for use with a new commercial vacuum tube. Molded of Kel-F, a polymer of trifluorochloroethylene possessing resistance to high temperatures, good mechanical properties, high dielectric strength and ready moldability, the base requires no machining and is ready for use when taken from the mold. Kel-F is produced by The M. W. Kellogg Co.*

Plastics Can Be Joined by Several Welding Methods

Many thermoplastic products now produced by molding, extrusion or cementing can be fabricated more satisfactorily and economically by welding standard sheets and sections together.

by **LEON M. JAROFF**, Assistant Editor, Materials & Methods

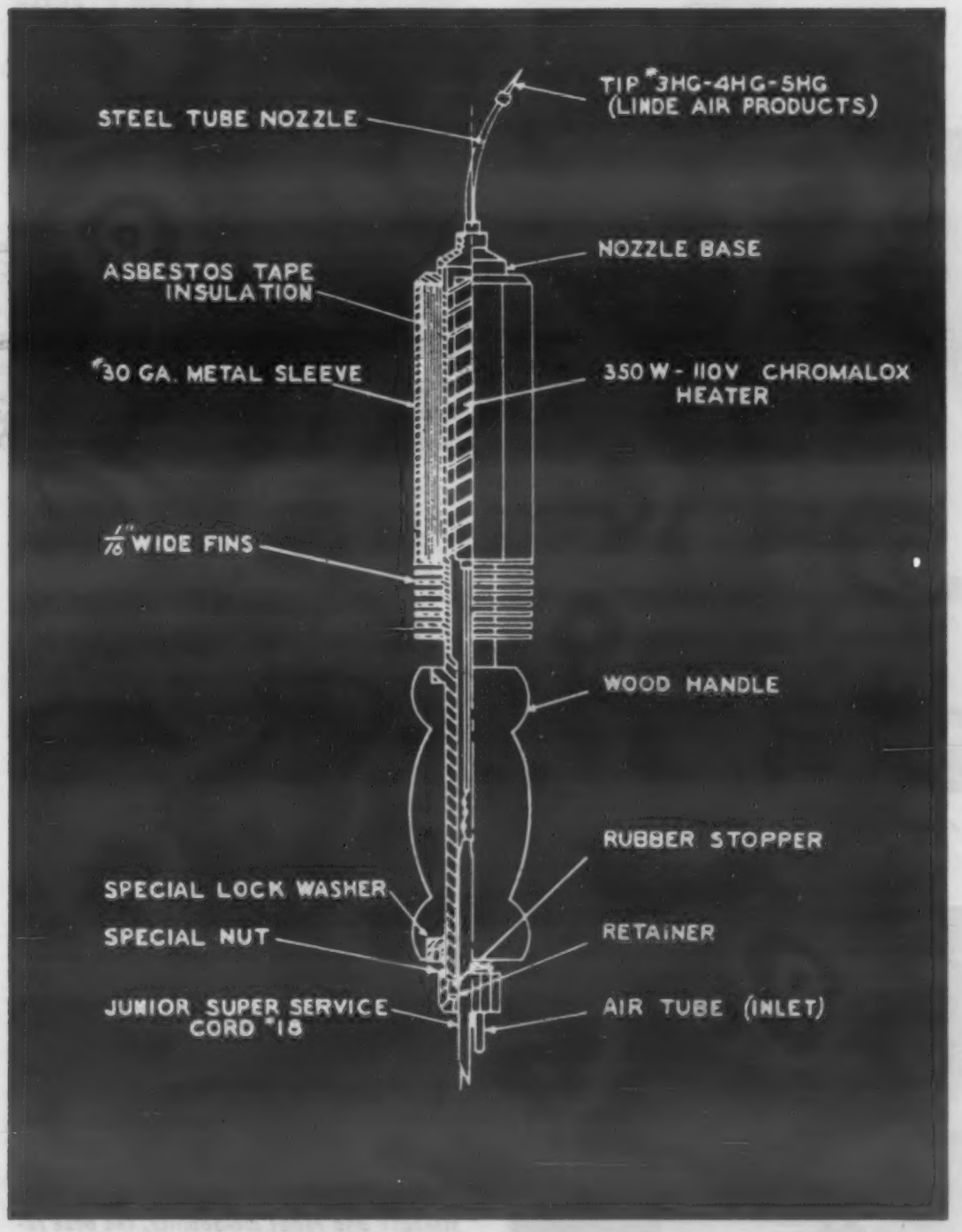


Fig 1—This hot air plastic welding torch resembles the torch used for welding metals, except that it directs heated gases, instead of a flame, against the work. (All illustrations courtesy The Dow Chemical Co.)

● TOWARD THE END OF World War II, when Allied research teams began to compile information about scientific and industrial war-time developments in enemy countries, it became apparent that Germany had achieved spectacular success with a process that had received scant attention in Britain and America—the welding of thermoplastic materials. Before her final defeat, Germany was producing such plastics articles as tank linings, pipe fittings, valves, fume and exhaust systems, electroplating hoods, and even footwear—all fabricated by welding.

Meanwhile, British and American industry, with little need for the extensive plastics substitutions resorted to in Germany, lagged far behind in plastics welding techniques and applications. Although some success was achieved in the high frequency heat sealing of plastics films, little progress was made in the joining of thicker sheets and more complicated forms. Since the war, however, wider use of plastics in industry and publication of detailed information about the German war-time developments have resulted in increased research into, and application of plastics welding processes.

Many manufacturers have begun to eliminate their more expensive molding and extrusion operations by welding standard sheets and sections into forms. Others are now able to use plastics in applications which were impossible before the development of proper welding techniques. And, most important of all, industry's distrust for plastics welding, which resulted from pre-war misapplication and misinformation, has been largely dissipated by post-war successes.

It should be emphasized, however, that welding is not a cure-all for plastics fabrication problems. Only thermoplastic materials can be welded satisfactorily, and even some of these have poor welding characteristics. In many applications, cementing produces as good a joint as welding and is more economical. Molding and extrusion, in turn, are usually less costly than welding when mass production of plastics articles is involved. Nevertheless, welding can be used profitably in the manufacture of many plastics products now being fabricated by other means and has made possible the use of plastics in an unlimited number of new applications.

In many respects, the plastics welding methods are similar to conventional welding processes used for metals. There is little difference be-

tween the gas welding of plastics and metals, for example, while high frequency welding of plastics has its counterpart in the spot and seam welding of metals. Many of the heated tool processes are similar to flash butt welding, and even the friction welding process used for plastics is now being applied to the welding of metals.

Hot Gas Welding

The technique which most closely resembles its metal equivalent is the hot gas welding of plastics. Here, as in metal welding, a gas torch and a filler rod are employed for butt, lap and fillet welding, the important difference being that a direct flame cannot be used because of the susceptibility of plastics to burning and charring. Instead, the welding gas passes through a stainless steel spiral which is heated either by electrical resistance elements or an oxy-coal, acetylene-air or propane-air flame and emerges from the tip of the torch at a temperature between 500 and 700 F.

In using the hot jet torch for welding a specific thermoplastic, it is essential to choose the correct welding gas and the temperature and pressure at which it leaves the torch for the thermoplastic being welded. Compressed air, nitrogen and carbon dioxide are the most commonly used gases, although oxygen and hydrogen are used in exceptional cases. It has been found, for instance, that the use of oxygen results in polyvinyl chloride welds of exceptionally high tensile strength, while carbon dioxide and compressed air produce substantially lower strengths in welds of the same material. With polythene, on the other hand, oxygen and even compressed air cannot be used because of the rapid oxidation and deterioration of electrical properties which occur.

The temperature and pressure of the welding gas also have considerable effect on the properties of the weld. Too low a temperature and gas pressure causes insufficient softening of the filler rod and the parent material, and results in a weld of low tensile strength. Conversely, a jet with temperatures and pressures that are too high produces bubbles in the weld and tends to blow the weld deposit off the center of the seam.

Ordinarily, gas pressures should vary from 5 to 15 psi, while temperatures of from 375 to 425 F are required at the surface of the weld for most thermoplastics. The gas should be approximately 200 F hotter at the orifice to compensate for heat losses

Fig 2—In this welding method parts are held against a heated plate until they soften sufficiently (top) and then are pressed together for several seconds (bottom) until the plastics solidify again.

in the gap between the tip of the torch and the workpiece.

The actual technique of hot gas welding plastics presents few difficulties to those already familiar with metal welding. For thicknesses up to 16 gage, no preparation of the plastic sheets or sections is required. Thicker materials should be beveled at the edges, the beveling angle varying from 55 to 80 deg. One end of the filler rod is then inserted into the chamfer, heated with the hot gas jet until it softens, bent into a right angle, and placed where the weld is to start. As it is hand fed into the joint under slight pressure, the filler rod is held vertically, while the welding gas is directed simultaneously against it and the edges of the chamfer at an angle of from 30 to 45 deg to the plane of the work. During the welding, a slight weaving motion of the torch is used to insure uniform heating of the filler rod and the parent material.

Speed of welding varies between 3 and 10 in. per min, according to type and thickness of plastic being welded, and attempts to increase the speed beyond these limits usually result in overheating, burning and improper fusion.

When a smooth surface is required, the finish weld can be machined. A stronger weld will result, however, if the slight crown left by the welding operation is not removed. In any event, joints made by hot gas welding do not reach their full strength immediately and should not be subjected to any stress for several hours after welding.

Polyvinyl chlorides have been used extensively for welding by the Germans, and the fact that greater quantities are now available in this country has contributed greatly to the increased use of gas welding here. The British gas-weld polythene to a limited extent, while gas welding of vinylidene copolymers is increasing in the United States. Some hot gas welding applications for polyisobutylene and polystyrene have also been reported from Germany and investigated here.

Heated Tool Welding

Heated tools and plates with temperatures high enough to effect depolymerization of the materials being welded are now widely used in welding plastics. After coming in contact with the heated surfaces, the softened parts are pressed together and held in place until the joint has solidified.

The first use of this process by the Germans was in the welding of plastics pipes for conveying corrosive fumes and chemicals. In this operation, the pipe ends are clamped into the jaws of a jig and a heated plate pivoted into position. When the pipe ends soften and become plastic, the plate is withdrawn and the pipes butted together under pressure. It is important that this butting operation be carried out with the least possible delay and that pressure be maintained long enough to prevent stressing of the softened material.

Because this process is difficult to apply in the confined spaces where pipes often have to be welded, a portable tool has been designed which accomplishes substantially the same results obtained by the more complicated set-up described above.

Another variation of hot tool welding is the "Saran" technique pictured in Fig 2, in which the pipes are applied to the hot plate and joined together manually. Pressures employed during the melting on the hot plate should vary from 3 to 12 psi, so that satisfactory melting without excessive flash can be obtained. The time required for melting on the hot plate varies widely, but an interval of 10 sec at the prescribed pressures should give the best results. During the actual welding the pressure between the two pieces must be sufficient to press out all air bubbles and to bring all surfaces into intimate contact. This method is employed in welding pipe and large tubing sections and can be used in the assembly of molded parts in which dimensions do not need to be too closely held.

Another even simpler type of heated tool welding is obtained by attaching a copper "shoe" to an ordinary soldering iron (See Fig. 3). In welding of plastics sheets to produce continuous linings for tanks and other similar operations, the electrically heated shoe is passed slowly between the two overlapping surfaces to be joined. It is followed immediately by a hand roller which presses the molten surfaces together and completes the weld. Carbonizing of the molten plastics on the shoe during the actual welding process is avoided by keeping the shoe in motion and in contact with both sheets. When the seam is completed, the plastic remaining on the shoe quickly carbonizes and can be easily brushed off.

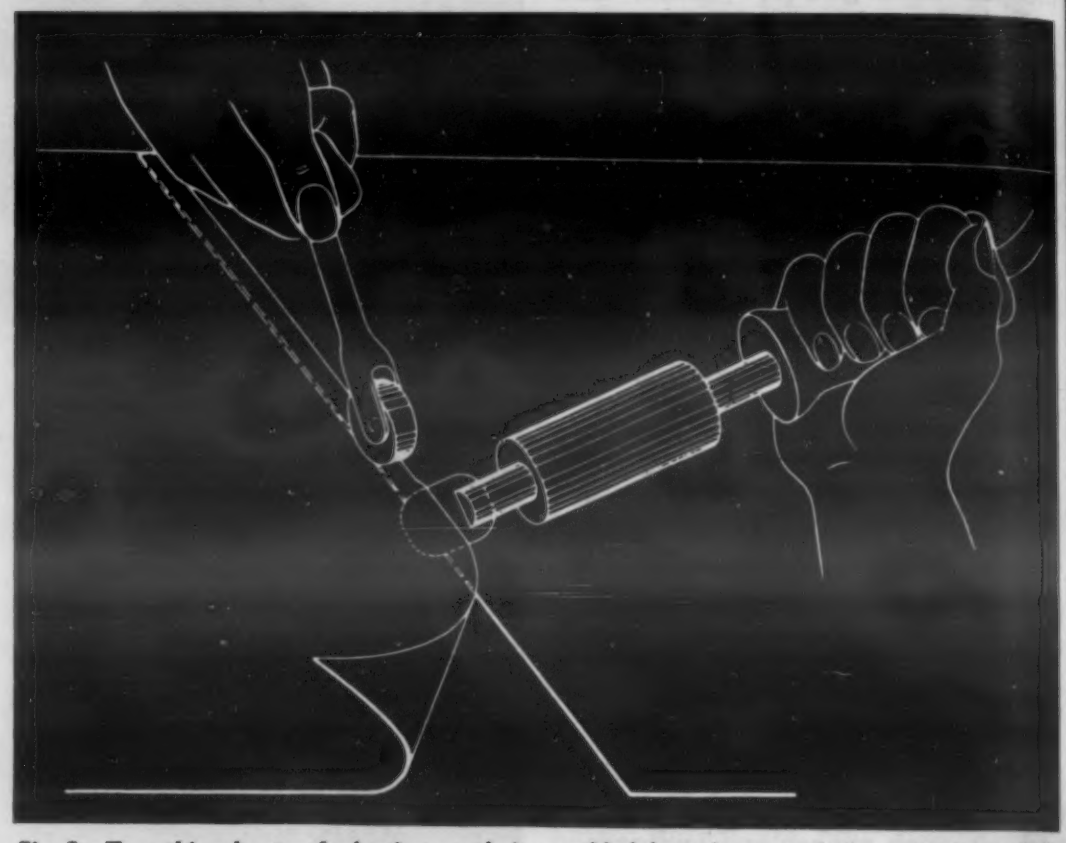


Fig 3—Two thin sheets of plastics are being welded here by one of the variations of the heated tool method. A follow-up roller consolidates the joint after the surfaces have been heated by the "shoe" attached to the soldering iron.

In all of these heated tool welding processes, the hot plates should be plated with nickel or chromium to prevent the decomposition that occurs in some plastics when they are brought in contact with heated copper or steel surfaces.

Heated tool welding has been used for many years to manufacture cellulose nitrate and cellulose acetate blocks from thin sheets of these materials. Other thermoplastic materials suitable for this joining process are cellulose acetate butyrate, nylon, polymethyl methacrylate, polystyrene,

polyvinyl chloride, and polyvinylidene chloride. Polythene can also be hot tool welded if a heated glass plate is used instead of the standard metal plate.

High Frequency Welding

Until recently, high initial costs made it preferable to join plastics by methods other than high frequency welding wherever possible. Although lower-cost high frequency heating units are now on the market, the production of relatively large quantities of plastics articles must be contemplated before the use of this equipment is economically justified. In many applications, however, high frequency welding, being adaptable to mass production techniques and able to produce high-speed, uniform welds, has proven to be an ideal method for joining plastics sheets.

Of the three general types of high frequency welding processes—spot, continuous seam and press welding—spot welding bears the closest resemblance to its metal counterpart. While the design of plastics and metal spot-welding machines is similar, there are two important differences. Spot welding machines for joining metals exert several thousand psi of pressure and use a welding time varying from a few cycles to a few seconds. Plastics welding machines, on the other hand, apply pressures which seldom exceed 100 psi and require ½ to 10 sec for actual welding time.

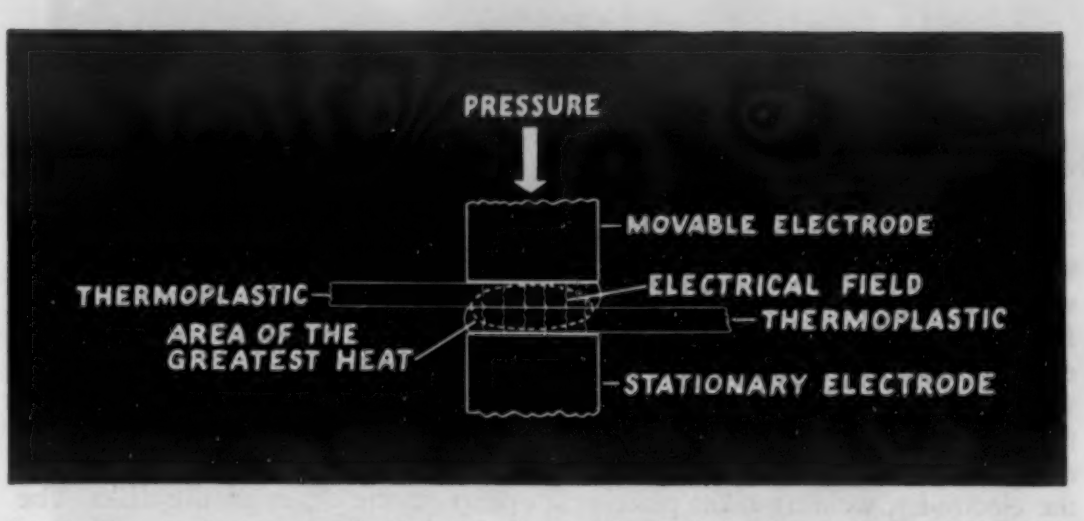


Fig 4—The simultaneous application of pressure and a high frequency electric field which causes heat to be generated in the area of the plastics sheets between the two electrodes results in the joining of thermoplastics by a process similar to spotwelding.

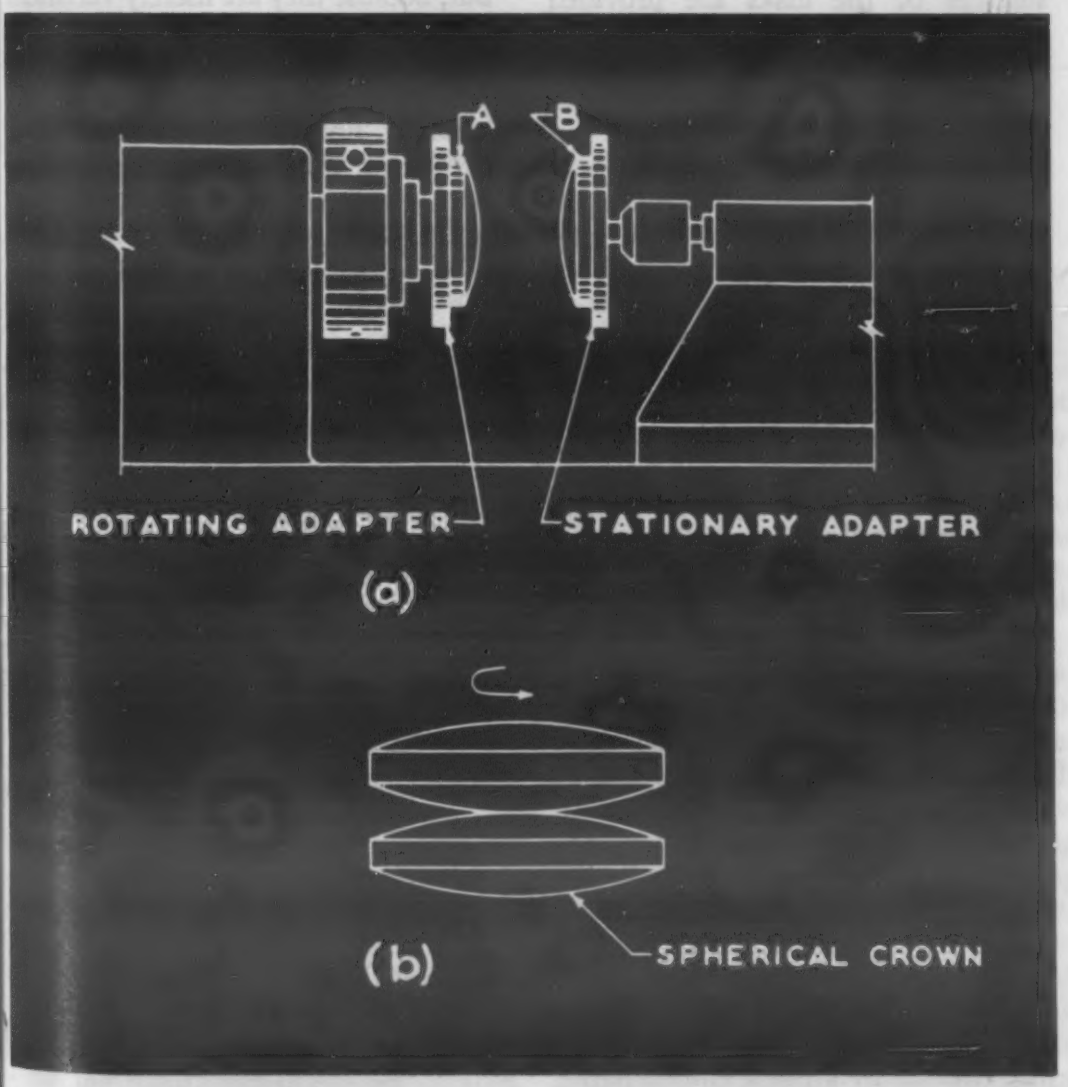
Insulated electrodes, one stationary and the other mounted in a moving, pressure-producing arm, are employed in typical spot welding operations. The plastics parts to be joined are placed in contact with the stationary electrode, and the mobile electrode is brought to bear on them with light pressure over the area of the joint. After the output circuit has been tuned to give the maximum power into the materials being welded, the high frequency power is applied for a predetermined length of time, rapidly heating the plastics, and then automatically cut off. Pressure is released only after enough time has elapsed for the plastics to solidify again.

A diagrammatic sketch of the method is shown in Fig 4. The field emanating from the electrodes passes through the plastics sheets, causing oscillation of the molecules which, in turn, results in friction and development of heat. The area of greatest concentration of heat lies within the dotted lines in the sketch. But heat developed at the surfaces in contact with the electrodes is dissipated by convection and conduction, minimizing the tendency of the plastics to stick to the electrodes.

Actually, the term spot welding as applied to welding of plastics is rather elastic. While it is customary in metal welding to use this term for circular spots only, there is a tendency in plastics welding to describe processes that weld straight lines and curved seams as spot welding also.

The design of the second type of high frequency plastics welder, the continuous seam welder, is a logical development of the spot welding technique. In fact, the continuous seam welder can be called a spot welding machine which produces overlapping spots as a continuous process. This is usually accomplished by passing the sheet or film to be joined between two moving rollers, each of which serves as an electrode to provide high frequency heating. Welding pressures between 25 and 300 lb are

Fig 5—Two disks are shown here mounted on a lathe (a) which is set up to friction-weld them together. The spherical crowns on the disks (b) insure that there will be sufficient friction near the slowly-moving centers of the disks to weld them properly.



used with these welders at speeds up to 50 in. per min.

One continuous sealer is able to continuously bond two 36-in. wide pieces of vinyl film together to give materials 72 in. wide, while simultaneously hemming the two outside edges at a speed between 45 and 60 ft per min. More widely used, however, is the sewing machine type, which is similar to a standard sewing machine but uses electrodes instead of needles. As the film passes between the electrodes, welding takes place at speeds of approximately 35 ft per min when combining two 0.004-in. thick vinyl films.

Another high frequency welder, called the platen press type or bar sealer, consists of an oscillator and a platen press with an electrode of any desired shape usually mounted on the top platen. The lower electrode is either identical to the upper one in shape or consists of a flat steel plate. Platen press welders and sealers have been developed with platen areas of more than 6 sq ft, carrying electrodes of intricate patterns. The larger the area of the seams to be bonded, however, the greater is the necessary output. High frequency oscillators most commonly employed for the fabrication of film range in capacity from 0.5 to 5 kw.

Since this type of machine welds at all points of contact, a great advantage is gained by using electrodes formed in the shape of the pattern desired. Inflatable toys, beach accessories, and mattresses are a few of the many items now being welded on all seams in one short operation. Although machined electrodes are widely used, it is possible to bend strips of copper, brass or steel to form satisfactory electrodes. This permits rapid changeover from one product to another without the expense of machined dies for special jobs.

Those plastics which meet the requirements for high frequency welding include cellulose acetate, cellulose acetate butyrate, nylon, rubber hydrochloride, monochlorotrifluoroethylene, polymethyl methacrylate, polyvinyl chloride, polyvinylidene chloride, and polysulfide plastic.

Other Plastics Welding Processes

Friction Welding. Heat for friction welding is produced by rubbing two parts against each other under the simultaneous application of pressure. Either a rotary or reciprocating motion is suitable to effect the rubbing, although the rotary method is more commonly employed. Long cylinders have been built up by friction welding a number of disks together on a lathe, using disks which range from ⅛ to ¾ in. in thickness and 3 to 6 in. in dia. In this process, one disk is held stationary in a tailstock adaptor while another is rotated in an adaptor fastened to the lathe spindle. The stationary disk is brought into contact with the rotating disk and pressure applied by means of the tailstock screw until melted plastic appears at the edges of the disks. The lathe spindle is then stopped, but pressure is maintained for several seconds until the weld has cooled enough to hold.

Actually, the process just described is more ideally suited for joining hollow plastics pipes than disks, because there is little difference between the circumferential speeds at the inner and outer diameters of the pipes. A rotating disk, however, can have a circumferential speed of several hundred feet per minute at the outer diameter, which decreases in direct proportion to the radius to a speed of 0 feet per minute at the center. So, if the friction welding of flat disks were attempted, very little heat would be generated at the centers of the disks, resulting in welds of poor quality. Instead, the contacting surfaces of the disks are provided with crowns, so that friction will develop first near the center and gradually spread toward the outer edges (See Fig 5).

With experience, the operator can determine what pressure is sufficient to produce good welds but, in any event, it should be great enough to force out any bubbles that appear at the joint. Too great a velocity, combined with too little pressure, will result in charring of the plastics and a poor weld.

Thermoplastics most frequently used in friction welding include cellulose acetate, cellulose acetate butyrate, cellulose nitrate, nylon, polymethyl methacrylate, polystyrene, polythene, polyvinyl chloride, and polyvinylidene chloride. It has been observed that some types of polymethyl methacrylate do not weld readily under these conditions. Differences in degree of polymerization are probably responsible for this variation in performance.

Flame Welding. Although use of a direct flame is usually injurious to plastics, it has been found that no appreciable deterioration of polythene occurs if the flame is properly controlled and not too hot. Flame welding, effected by a finely tipped flame, can be applied to joining thin films of polythene for moisture-proof packaging of small articles such as cigarettes and certain food products. Using a little skill, a welder can also employ flame welding to join comparatively thick sheets of polythene, but gas welding is usually preferable. Flame welding produces best results when applied to grades of polythene which have molecular weights above 6,000 and, preferably, higher than 10,000.

Radiant Heat Welding. This method is similar to heated tool welding except for the fact that the surfaces of the plastics to be joined never come in actual contact with a heated metal or glass tool. Instead, the surfaces are brought to the proper temperature by radiant heat which is emitted from hot electrical resistance wires. As soon as the two surfaces to be joined have softened sufficiently, they are placed together in a press under enough pressure to cause the material at the joint to flow. In this manner, all air bubbles are forced out and a satisfactory joint assured. Pressures usually range from 125 to 500 psi, and should be maintained until the material is cool and set so as to avoid warpage in the finished part.

Several other techniques are now being investigated or used by industry but, because they are merely variations of the processes described above, no attempt has been made to include them in this general survey of plastics welding. Enough discussion has been presented, however, to acquaint the reader with the basic plastics welding techniques and the new field of plastics fabrication that they have made possible.

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Acknowledgment

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Tennessee Eastman Corp.

Copper brazing paste being applied by brush for furnace brazing. (Courtesy Corcoran Metal Products Div., McCord Corp.)

New Copper Paste Permits Brazing Economies

Hand labor and waste is largely eliminated by using copper brazing paste instead of pre-placed forms.

by KENNETH ROSE, Western Editor, Materials & Methods

• COPPER BRAZING has long been recognized as a valuable method for joining steel with a permanent bond that is easily made in furnaces by mass production methods. For small parts that can be placed on a chain conveyor, held in fixtures, or loaded into alloy trays or baskets, run into a controlled atmosphere furnace, and held at the proper brazing temperature, copper brazing can show high production rates with little manual labor involved.

However, one of the operations that has required use of manual labor has been the placing of the copper, whether as disks of copper foil in butt or slip joints, or as rings of copper wire, or in special form. Waste in handling the copper forms for preplacing has always been considerable. Both the making of the forms and placing them in the work have required hand labor in most cases, and the fragile nature of the forms has increased the waste. In spite of these disadvantages, copper brazing has won wide use because of its overall economies.

Use of the copper brazing material as a paste with semi- or fully-automatic application rather than as metallic copper foil, wire, etc., affords the possibility of savings in use of the material and in the labor of applying it. A combination of made-up brazing paste and complete equipment for applying it is offered by The Glidden Co., Metals Refining Div., Hammond, Ind.; the trade name of the paste is Cubond. The paste is practically nonsettling, dries slowly so as not to clog guns, and can be thinned with appropriate solvents.

Hydrogen or cracked natural gas atmospheres, either pure or with a little natural gas added, are suitable for use with the paste as with the metallic copper brazing wires and foils. The natural gas is helpful if the steel is of medium or high carbon content, and must be protected against decarburization. Use of excessive amounts of carburizing gases can cause sooting of the work or damage to the heating elements in electric furnaces.

Equipment for Applying Paste

The equipment for using the paste can consist of either a simple plunger type mechanism that squeezes ribbons

or globules of the paste, properly thinned, onto the work from a nozzle, or a compressed air feed from a storage tank through a small gun. The first-mentioned device acts as a syringe, drawing paste into a cylinder by suction when the nozzle is placed under the surface of the thinned paste and the plunger is drawn back; the paste is then applied to the work from the same nozzle. With the compressed air applicators, it is possible to mix larger batches of the paste where mixing is desirable, to control the amount of paste applied to the work by regulating the size of the drop or of the ribbon delivered, and to obtain higher production with less work upon the part of the operator. Compressed air can be obtained by attaching to any 25- to 30-psi supply. Neoprene rubber hose is used to carry the paste to the gun. A range of tip sizes is available.

Typical applicator units and parts for use with Cubond in furnace copper brazing.

Applying Cubond to a refrigerator condenser by dipping. (Courtesy Corcoran Metal Products Div., McCord Corp.)

A wetting agent has been incorporated into the paste formulation. This helps the paste to spread uniformly, even when the metal surfaces retain a little oil. Metal parts badly contaminated with oil should be degreased and other dirt should also be removed. An antispattering agent in the paste tends to prevent the paste globules from separating from the work before melting. Iron, included in several formulations, is added in very finely divided form. Fluxes are included in the paste in some formulations.

The iron serves a double purpose in the paste. It (a) decreases the fluidity of the molten copper during the actual forming of the bond; and (b) increases the strength of the brazed joint by better filleting. Joints as wide as 1/32 in. have been filled. The iron formulation has lowered fluidity also, and can be used where such property is required, as well as for increased strength.

Typical Applications

At L & L Manufacturing Co., Van Dyke, Mich., tube fittings, hose couplings and pipe fittings are made for high pressure hydraulic use. These have been assembled by copper brazing with the copper applied as slugs and rings. The brazing is done in a controlled atmosphere electric furnace. The parts to be assembled are of low-carbon open hearth steel, with most of the parts of C 1119 stock.

Brazing is now done with Cubond using the type without iron for most work and the type containing 4% iron for occasional loose fits. The paste is thinned slightly with kerosene until it is of the consistency of molasses. When the threaded parts are to be assembled into the bodies of the fittings as press fits, the paste is applied to the abutting shoulders by means of a plunger syringe with a needle nozzle. Because of the fluidity of the molten copper, it is not necessary that a complete circle be made with the Cubond. It will flow into the joint space by capillarity if touched to several places along the joint line. Where the fit-up is loose, with clearance of 0.0001 to 0.001 in., instead of the negative clearance of the press fit, the iron-bearing composition is applied. The pieces are not dried as a separate operation, but are dry by the time the work enters the heat zone of the furnace.

Brazing is done in the electric furnace and requires about 4½ min at 2050 F. The pieces are cadmium plated after brazing. The company reports the following advantages over brazing with preplaced copper:

1. Increased strength of joint.
2. More uniform flow of the brazing material, reducing the number of rejects due to lack of bond.
3. Improved filleting.
4. Reduced assembly time due to the lessened amount of hand work with the paste.

General Motors' Transmission plant of Saginaw-Chevrolet Div. is using Cubond to braze the shifter fork and the shifter shaft and plate assemblies. Formerly, these operations used copper rings for preplacing of the brazing material. As the wear parts are of SAE 1040 steel and are locally hardened after assembly, no decarburization can be permitted. The parts are assembled with a 0.002-in. press fit. Cubond is then applied to the joint line from a gun with a needle nozzle, which is fed from a storage tank and with a 25 to 30 psi of pressure applied by the plant's compressed air system. Application of the paste is made just before the work is moved into the brazing furnace. Press assembly is made in a preceding operation and the pressed pieces are staked to preserve absolute alinement. The brazing is done in electric furnaces with hydrogen atmosphere, operated at 2050 F.

After the brazing operation the tips of the shifter forks are hardened by induction. The shifter shaft and plate assembly require the hardening of a detent notch, and this is done by flame hardening.

Cubond is substantially more economical than the rings formerly used, General Motors engineers state, but a little messier for the operator. When the paste application of the brazing compound was first introduced into the shop the workman didn't like it, but after using it for a while they reported that it was easier on their hands than the preplacing of the metallic rings.

The paste is thinned to the consistency desired for easy operation with the gun. It is stored in a 5-gal. tank in which a stirrer is driven slowly during use. At present rates of production the operation uses about 3 qt of the paste in 16 hr.

Materials & Methods Manual

This is another in a series of comprehensive articles on engineering materials and their processing. Each is complete in itself. These special sections provide the reader with useful data on characteristics of materials or fabricated parts and on their processing and application

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Nondestructive Testing of Engineering Materials and Parts

by R. C. McMaster, Supervisor, and S. A. Wenk, Assistant Supervisor, Battelle Memorial Institute

Most of us are not familiar with all of the many nondestructive testing methods developed in recent years for detecting defective materials and parts. It is particularly important that engineers and technical management be informed about them, because proper selection and use of nondestructive tests can significantly reduce manufacturing costs and improve product quality. The purpose of this manual, therefore, is to bring together in one place the basic facts about all the available methods, and, by describing the capabilities and limitations of each, to serve as a basic guide to proper nondestructive test selection.

Contents

Introduction

Why does a component fail? Assuming calculated design stresses are not exceeded, failure under normal service conditions occurs because the material or component is defective in some manner. Defects which cause failures are of many varieties; however, they generally are characteristic of the material and its method of processing and fabrication. A partial listing of such defects shows their wide variety:

(a) Excessive segregation or inclusions
(b) Internal cracking
(c) Porosity
(d) Seams, laps, score marks, and other rolling defects
(e) Forging bursts
(f) Machining and grinding defects, such as surface stress concentrations, grinding cracks, etc.
(g) Inadequate penetration in welding
(h) Inadequate or improper dimensions or sections
(i) Improper chemical composition
(j) Improper internal structure

Since most of these defects are hidden beneath the surface, they can best be detected by nondestructive testing. It is the purpose of this manual to acquaint the reader with the presently available commercial forms of nondestructive testing, their capabilities, and limitations. It would be impossible to cover all of the many nondestructive tests in the space allotted. Therefore, this manual has been limited to the common and most widely used methods for detecting one or more of the defects listed above; namely, penetrating radiation, mechanical vibration, magnetic-particle, penetrant, magnetic induction, and triboelectric nondestructive tests.

It is important that engineers in management and in operations have a fundamental understanding of the art of nondestructive testing, and of the presently available commercial methods, so that they can select or specify nondestructive tests which will best achieve the desired purposes. It is important that they know what the various methods can and cannot do, and what their proven applications are in order to avoid costly misuse.

It is particularly important that they have such knowledge because proper selection and use of nondestructive testing can significantly reduce manufacturing costs and improve product quality. The proper nondestructive test applied at the earliest point in the production process at which reliable inspection is possible will discover defective materials or parts and thereby eliminate further fabrication costs on those units containing internal defects. This, for example, is particularly valuable where costly machining processes are involved, since these machining costs on defective units may be saved by early inspection. Nondestructive testing is also an invaluable aid in the development stages of designing and producing products.

That nondestructive testing is successfully accomplishing its function of reducing costs and improving quality is now quite apparent. Today, American industry is spending millions for nondestructive test equipment, tens of millions for the supplies and labor to operate the equipment, and is using the equipment to test and inspect billions of dollars worth of materials, parts and assemblies.

Basic Characteristics of Nondestructive Tests

Nondestructive tests detect and evaluate defects, or measure the strength or serviceability of materials, parts, assemblies and structures, without damaging or destroying the test objects. They differ from *proof* tests and from *coupon* tests. In *proof* tests, the test objects are loaded to a proof stress at which unsatisfactory specimens should be revealed by their failure. In *coupon* tests, a selected portion of many objects are tested to destruction, as an indication of the probable quality of the entire group. Both proof and coupon tests are destructive.

Nondestructive tests differ also from the ordinary measures of industrial *process control.* With process control, limits in material composition, structure and properties, and controls on processes, machine operations and dimensional tolerances are applied to insure consistent high quality in the resultant product. However, some defective units can be produced even with good process control. Such defects must be detected by other means.

Most nondestructive test methods involve far more than external visual *inspection* of the surfaces. In most cases, the nondestructive test is designed to reveal the properties and dimensions of the interior of the test object, without the need of sectioning or destroying the test object to make the interior visible as a new external surface. Nearly every basic principle of physics has been used to obtain, nondestructively, necessary information concerning the properties of the internal parts of test objects.

Essential Elements of Nondestructive Tests

Most nondestructive tests depend, for transmission of information concerning the object under test, upon mechanical measurements or upon a flow or transfer of energy. The five essential elements of most nondestructive tests are:

1. A suitable form and distribution of energy supplied to the test object, usually from an external source, such as an x-ray tube, a magnetizing coil, or an ultrasonic generator. This energy can be distributed rather generally through the object being inspected, as with a broad x-ray beam, or concentrated in a narrow beam, as in ultrasonic testing.

2. Modification of the energy distribution within the test object, as a result of defects or variations in material properties which correlate with serviceability.

3. Detection of the energy modifications by a sensitive detector. Often, only a small portion of the incident energy is affected. For this reason, very sensitive detectors of the energy changes are required in order to obtain indications of the presence and nature of defects or variations in properties in the test object.

4. Indication or recording of the energy measurement from the detector in a form useful for interpretation, such as an x-ray film.

5. Interpretation of the indication or record, and judgment of the corresponding serviceability of the test object.

The practicality and effectiveness of a proposed nondestructive test method must be evaluated by a full consideration of each of these essential phases.

Reliability of Tests and Inspectors

In most nondestructive tests, it is necessary to detect and evaluate flaws and defects, or to determine strength and serviceability, by *indirect* procedures. These predictions of strength or service performance usually involve the measurement of a different but correlated property. A necessary prerequisite to a reliable nondestructive test is a *proven correlation* between the property actually measured by the nondestructive test, and the strength or serviceability property being predicted from the measurement. Where such correlations have not been fully established, evaluations are based upon the experience and judgment of skilled inspectors. In most cases of doubt, inspectors using nondestructive test methods tend to be conservative, particularly in the absence of reliable service data. Often, parts so rejected because of defects shown in the nondestructive tests have shown no weakening because of the defects when subjected to proof tests.

In evaluating nondestructive test methods, it is important to discriminate between the *reliability of the test method* (in revealing flaws or defects and in measuring the physical properties of test objects) and the *reliability of the judgments of the inspectors* (based upon the evidence revealed by the nondestructive method).

Selecting the Proper Test

Nondestructive tests are *specific* to the problem involved. There is no such thing as a general nondestructive test applicable to every kind of material, part or structure, nor to all their functions or operating conditions. Instead, selection of a nondestructive test must be based upon a thorough understanding of the nature and function of the part being tested and of the conditions of its service.

Nondestructive tests have certain geometric limitations in their scope and sensitivity. Some test methods require access to both sides of the part, material or specimen which is under test. Other methods can be modified for use as "one-side" tests. Some test methods can be applied to parts of almost any shape or size. Others are limited to areas with reasonably flat surfaces or with constant-thickness sections. A few types of nondestructive tests are applicable only to specimens of exactly identical geometry. Other tests are limited, at present, to certain kinds of materials or to parts with definite thickness limits. Some nondestructive tests allow large areas or volumes to be inspected in a single operation. Other test methods require scanning of each small area suspected of being defective. These limitations must be understood and appreciated before specifying a nondestructive test for any particular application.

The sensitivity of every type of nondestructive test is limited. Sensitivity adequate for excellent testing on one part may be totally inadequate for another test object. In general, more sensitive tests require more elaborate equipment and cost more. The cost of inspection must be considered in every application. Nondestructive tests which cannot be applied economically in the specific application will usually be abandoned.

It is desirable to limit the number of functions or properties to be measured by the nondestructive tests to those of practical importance in production or service. For example, a particular part might be weakened for service by any one or by a combination of several possible causes. These might include improper material; wrong heat treatment; internal defects, such as porosity, shrinkage, segregation, dross, inclusions; or external defects, such as cracks, surface notches, defects in plating, and so on. No single nondestructive test should be expected to measure reliably all of these properties. Often a separate type of nondestructive test is required for each general type of defect or cause of weakening.

The same reasoning holds true for service damage. Corrosion, repeated stressing, wear, impact, surface destruction, and many other factors may contribute to service failures of parts which were originally sound. Usually a separate method of inspection may be required for each of the types or locations of service defects.

The interval between repetitions of nondestructive tests used to detect service damage may vary with the types of defects. If specific nondestructive tests for each of the causes of failure are pyramided into large, complex nondestructive tests, the costs would ordinarily be unreasonably high. Nondestructive testing should be applied only to those properties which cannot be more economically or reliably controlled through other methods of process control or inspection.

Often, many causes might produce weakening of the part. If only a few of these particular types of defects have been selected for nondestructive testing, the correlations obtained between these nondestructive tests and the service performance of the parts may be poor (unless the other causes for weakening or failure are controlled or accounted for). Suppose that a choice exists between alternative methods of nondestructive testing, one of which measures only one cause of weakening, while a second measures several important causes of weakening. The latter test may be more reliable on the whole, even though it is less accurate or sensitive in certain specific measurements than the former test.

The costs of industrial nondestructive tests used in production can be greatly influenced by the proper selection of test methods and schedules. It is usually advantageous to use the lowest cost nondestructive tests first, and more costly nondestructive tests later, if several tests are required to evaluate a product. When a large proportion of the units inspected prove to be defective, this avoids the use of the high-cost method on these defective units. Many industries employ a low-cost nondestructive test method to scan all the units in production, eliminating all major defects immediately. The remaining units are then subjected to percentage nondestructive testing with higher cost tests to establish quality control over the process.

Penetrating-Radiation Methods

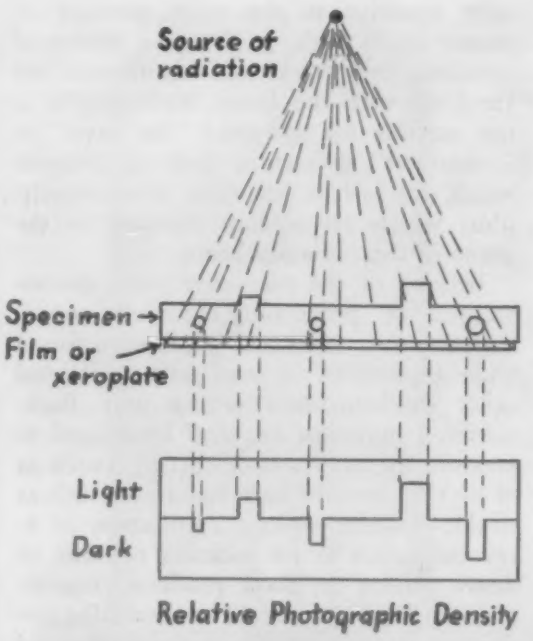
Penetrating-radiation nondestructive test methods now commercially available have been applied throughout a wide range of materials and components. They are an invaluable means of industrial nondestructive inspection. Present industrial inspection techniques employ many varieties of penetrating radiation or beams of high-energy particles. These include x-rays, gamma rays, Grenz rays, neutron beams, ion beams, electron beams, etc. Recent developments in the field of nuclear energy have made available new sources of high-energy particles and radiation suitable for nondestructive test applications.

In penetrating-radiation nondestructive tests, the test objects are exposed to beams or fields of the penetrating radiations or high-energy particles. The intensities of these beams are modified by passage through or reflection from the materials and defects in the test objects. The differential absorption of the radiation or particles is a function of the material structure, density, mass, thickness, and other properties of the test object. Scatter, internal reflection, diffraction, and production of secondary radiation within the test object introduce additional variations. The penetrating power (quality) of the radiation and the exposure must be carefully selected in each case to produce the maximum useful image with a minimum of objectionable secondary effects.

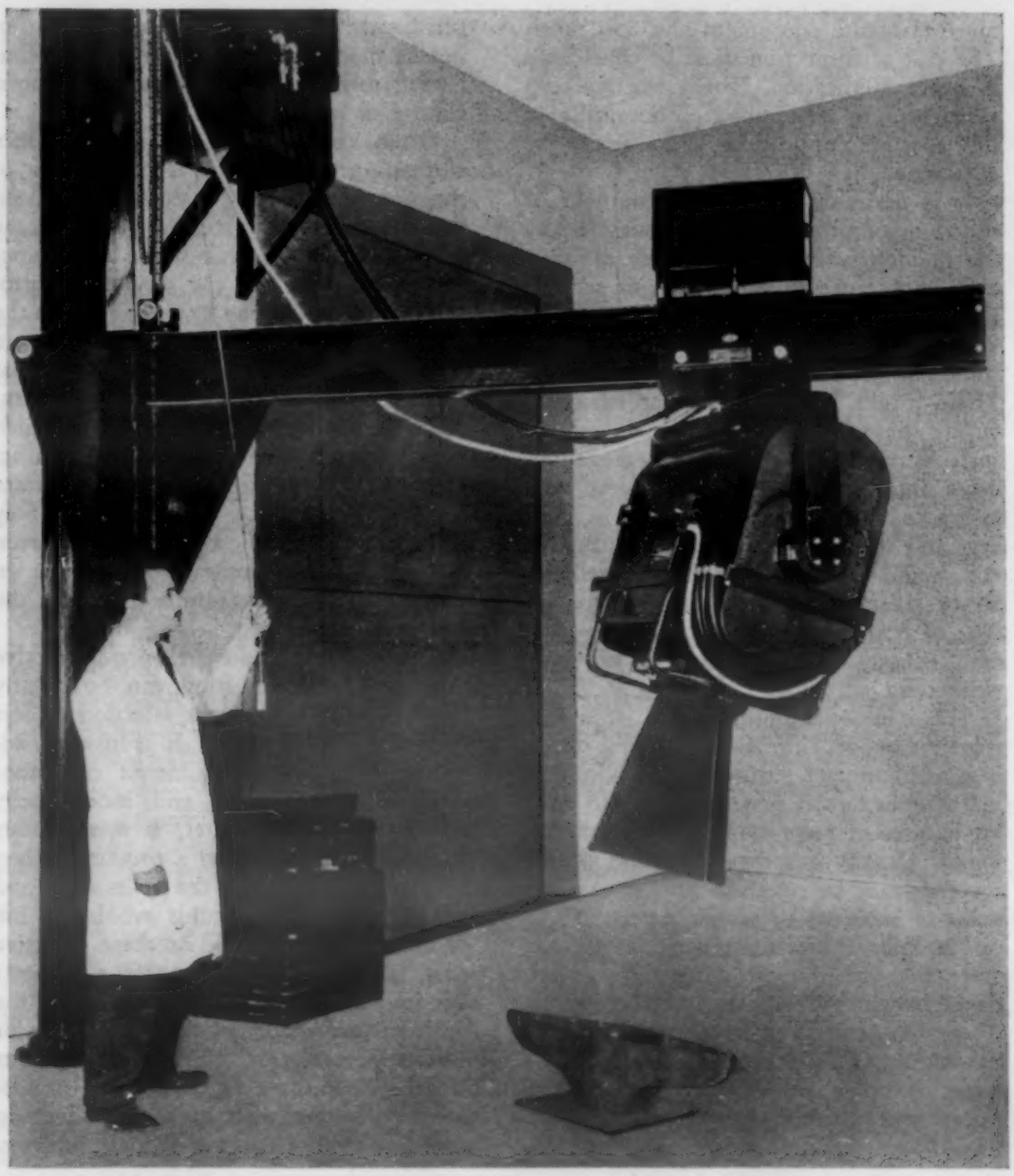
Sensitive radiation detectors, such as x-ray film, xeroradiographic plates, fluorescent screens, Geiger tubes, crystal counters, and ionization gages are employed to transform differences in intensity of the radiation into visible images or electrical signals.

Uses

Penetrating - radiation nondestructive tests have a large variety of proven applications in industrial nondestructive testing. They are an excellent means of recording inclusions or voids of irregular shapes located randomly within the test object. They reveal hidden or interior surfaces and contours, so that casting misruns, misfits in assembly, and errors can be readily detected. Film radiography pro-



Schematic sketch showing how x-rays or gamma-rays are used to detect internal flaws.



This industrial x-ray machine is being positioned prior to x-raying casting shown on floor. (Courtesy Picker X-ray Corp.)

vides an excellent means of testing fusion welds for porosity, lack of penetration, internal cracking, and other defects.

Since the radiation used is fundamentally sensitive to the mass quantity of matter in its path, it is a poor means of revealing thin cracks and laminations not lined up with the beam. Radiography is not suitable for revealing "flat spots" or "penetrator" defects in flash or pressure welds, since these are thin, discontinuous films which are seldom oriented in the plane of the radiation beam.

Because of the mass-absorption characteristics of penetrating-radiation nondestructive tests, thickness gages have found wide application in steel strip mills and other sheet-thickness gaging jobs. Back-scattered radiation has also been used to measure the thickness of coating (such as of tin) on metallic-base materials (such as steel). Another unique application of x-ray inspection is for locating metallic or dense objects in food products, organic resinous bodies, and other nonmetallic test objects. Because of the high contrast of metallic inclusions in nonmetallic objects, fluoroscopy is often employed for these inspection problems.

It is of interest to note that radiographic inspection and ultrasonic or magnetic-particle inspection supplement each other very effectively. Magnetic-particle inspection responds most sensitively to surface defects, such as fine cracks, laminations, and other closed defects which approach the surface of the part. Radiographic inspection responds best to deep-lying cavities which ordinarily are not well detected by Magnaflux. The combination of the two inspection methods provides a rather successful over-all technique. Ultrasonic-reflection nondestructive testing correspondingly is a suitable supplement for radiography. For example, radiography fails to reveal laminations transverse to the direction of the x-ray beam. Ultrasonic reflections from such laminations make it possible to locate them sensitively and effectively. Thus, although radiography is often considered to be an over-all nondestructive test revealing many different kinds of defects, frequently it is advantageous to use it in combination with other methods of nondestructive testing, such as MagnaFlux or ultrasonic.

Radiation Sources

The two principal sources of penetrating radiation are x-ray genetrating equipment and the radioactive materials, radium and cobalt 60.

X-Rays—X-rays are generated in x-ray tubes by directing a stream of high velocity electrons against a tiny target of tungsten. In general, the voltage rating of the x-ray equipment, which is usually given in terms of kilovolts peak (kvp), must be selected to correspond with the thickness and density of the material to be inspected. Very low voltage sources of Grenz rays (5 to 15 kvp) are suitable for the inspection of plastics, wood, paper, thin metallic foils, and other materials of low density or very thin form. X-ray sources rated from 15 to 50 kvp are employed in radiography of thin sections (up to ½ in.) of light alloys, of sportwelds in aluminum- and magnesium-alloy sheets, of components containing molded plastic parts with metallic inserts, and similar applications. The range from 50 to 120 kvp is employed in medical radiology and fluoroscopy, as well as for the industrial inspection of light-alloy castings and forgings for the aircraft industry. It is suited, in general, for light-alloy parts up to 2 in. in thickness or ferrous parts up to possibly ½ in. in thickness. The range from 120 to 400 kvp is widely used in industrial x-ray inspection of ferrous steel parts up to several inches in thickness.

There are few commercially available sources rated between 400 and 1,000 kvp. High-voltage x-ray sources, rated 1,000, 2,000 and 10,000 kvp, have been developed in the last ten years. These are now coming into industrial prominence for a wide variety of nondestructive testing jobs. The density differences between light-alloy and heavy-alloy materials tend to be decreased in this higher voltage range. Consequently, it is possible to reveal in a single exposure wide differences in section or in material density. Very excellent images can be produced from assemblies and composite test objects, as well as from various ferrous and heavy-alloy sections.

As can be seen from the preceding examples, the kvp rating establishes the penetrating power or quality of the x-ray beam. It must be carefully selected to make it possible for the radiation to penetrate the test object with a sufficient quantity of x-rays to produce a suitable image, yet be differentially absorbed sufficiently to produce a high-contrast image.

A variety of new particle accelerators have recently been developed as sources of penetrating radiations. The Betatron provides radiations in the range from two million to one-hundred million or more volts. Ten-million volt and 25-million volt units are now available commercially. The Betatron sources produce relatively narrow beams of radiation with very high penetrating power. They usually require a relatively larger space than conventional x-ray sources, since the test object, if of large size, must be located a distance of several feet from the port of the source. Several modified particle accelerators have been developed in the laboratory, but are not yet in wide industrial use.

Radium and Cobalt 60—Radium has long been a commercial source of penetrating radiation for nondestructive testing.

Exposure capsules contain from 25 to 1,000 mg or more of radium. Radon, a radioactive gas, is also supplied in capsule form for this purpose. Such radioactive sources must be handled in heavy lead containers between exposures. Due caution must be taken to prevent accidental exposures of personnel during the handling and placing of the radioactive sources. Because of their extremely low rental cost, such radioactive sources have many advantages for laboratories not equipped with electronic x-ray sources.

Radium sources, with a half-life of the order of 1700 years, have recently been supplemented by many pile-produced radioisotopes. These isotopes have much shorter half-life values and lower initial costs. Cobalt 60, for example, with a half-life of 5.3 years, emits gamma rays of 1.17- to 1.33-million volt energy. Cobalt 60 sources, equivalent to approximately 320 or 640 mg of radium, are now commercially available.

The low initial cost of cobalt 60, compared to that of radium, permits the economical use of intense sources for industrial radiography. This makes economical gamma radiography available to small foundries and other industries whose volume of business requiring radiography does not justify the purchase of the more expensive x-ray machines. It is a matter of economics, however, to establish which of the radioactive sources provides the lowest cost over a long period of time in industrial radiographic inspection applications.

Film Radiography

Radiography on x-ray film is a well-developed art. This method of recording x-rays has been in use since the discovery of x-rays.

Film recording is used for applications in which it is desirable to reveal the properties of the entire test object or of a large area in a single exposure. It has the great advantage over many other forms of nondestructive testing in that it reveals many different types of defects sensitively and does not require point-by-point scanning. It also provides a permanent record from which interpretations can be made at any future time. Of course, skilled film interpreters, well informed on the nature of the material, parts and applications under inspection, are required to evaluate the radiographic images produced on x-ray film.

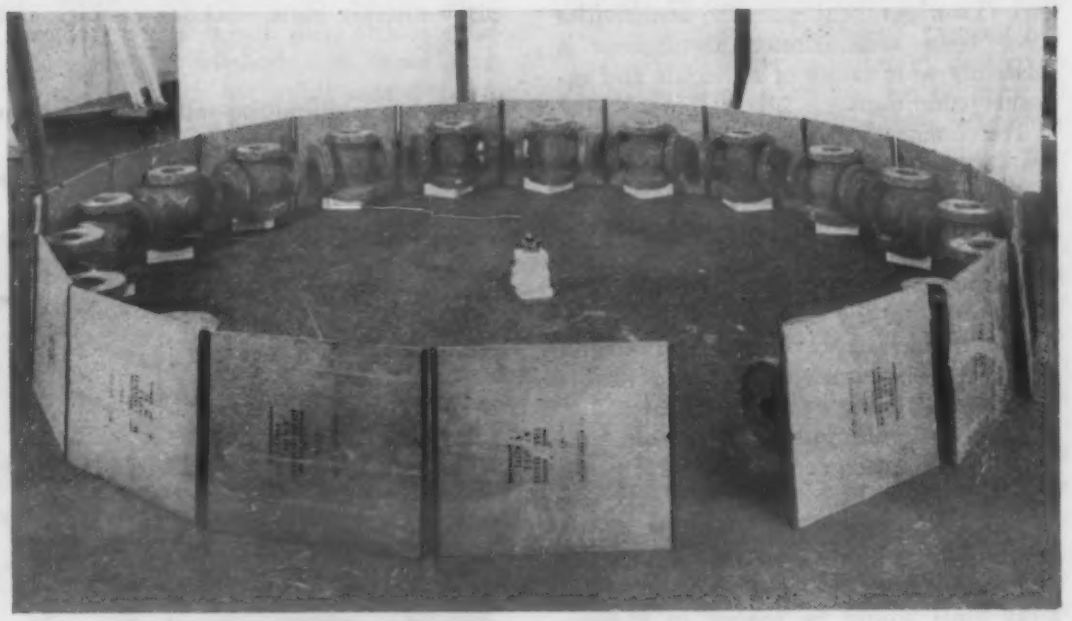
X-ray films are available in a number of different speeds and grain sizes to meet the various conditions encountered in practice. X-ray films differ from photographic films in that extremely heavy emulsions are coated on both sides of the base material. This is done in order to get the maximum response to x-rays and the highest possible densities in the resultant images. Industrial radiographic films usually have a maximum density of the order of 4.0 H & D units to provide wide latitude and high contrast sensitivity. Most x-ray films are exposed and developed to be appreciably denser than photographic film. Typical densities in industrial inspection are of the order of 2.7 H & D units.

Careful chemical processing of x-ray films results in uniformity of reproduction of density and in extremely high-quality images. In the normal kvp range, it is possible to reveal changes in thickness of the order of 2% of the total thickness of the part, by changes in film density of the order of 0.02 H & D units. Thus, penetrameter gages providing 2% contrast sensitivity are readily revealed in the normal industrial range of film radiography. With specimens of constant thickness, it is usually possible to reveal 1% contrast sensitivity with radiography on x-ray film. In the radiography of spotwelds, contrast sensitivities approaching ¼ of 1% have been obtained consistently under industrial x-ray inspection conditions with fine-grained films such as Type M and Superay B.

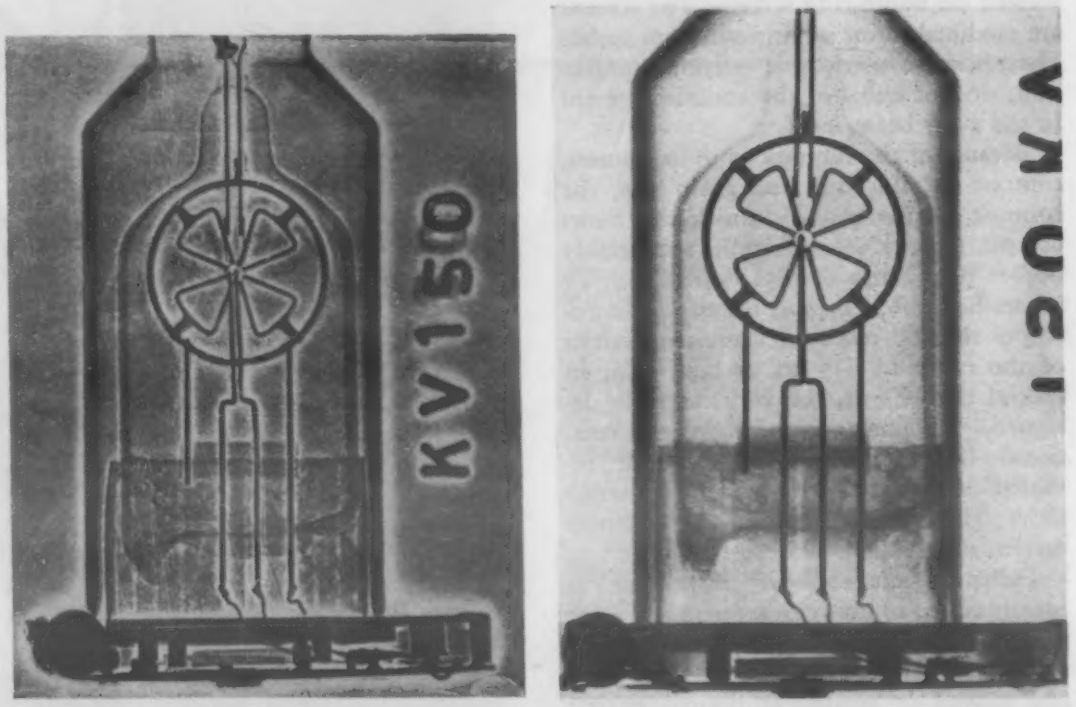
Xeroradiography

Xeroradiographic images are recorded on a sensitive photo-insulating film. This film, usually selenium, may be deposited on a metal backing plate such as brass or aluminum. The xeroradiographic plate is charged prior to exposure by passing it under a corona-discharge wire at a high potential. After charging, the xeroradiographic plate is sensitive to light or x-rays. It is handled like x-ray film (under red safelights or in suitable cassettes or plate holders).

Exposures are comparable to those with x-ray film. Typical exposure speeds are of the order of three times those of Type M film used without screens. After exposure, the xeroradiographic plate can be developed almost instantly by cascading over it a two-component, dry-powder developer or by exposing it to a cloud of charged



Typical set-up for radiographic inspection using gamma rays. Capsule containing radioactive source is in center. (Courtesy New York Naval Shipyard)



Radiograph (left) and xeroradiograph (right) of a tunable magnetron tube. (Courtesy U.S. Army Signal Corps Research Laboratories)

pigment particles. Thus, the image is available for inspection a few seconds after exposure is completed.

If a permanent record is desired, a sheet of ordinary paper is laid over the developed xeroradiographic plate, and the assembly is again passed beneath the corona-discharge wire. The electric field transfers the pigment from the plate to the paper. By using pigmented organic resin particles in the developer, the images can be fixed by exposing them to heat for a few seconds. This can be done with an infrared heat lamp, or more quickly with a small hot-plate press. The xeroradiographic plate can then be cleaned by cascading over it a powder with suitable triboelectric properties, thus making it ready for recharging and re-exposure.

Xeroradiographic equipment will soon be made available commercially. The process is still undergoing further development to produce improved images. Present xeroradiographic plates have been shown suitable for operation from 5 to 10,000 kvp. Two per cent contrast sensitivities have been demonstrated throughout a relatively wide range of materials and exposure conditions.

The basic advantage of the xeroradiographic process is its speed—since the images are available almost instantly after exposure—and its low cost. The xeroradiographic plate can be used again and again for hundreds of exposures. The only materials used are the ordinary paper and the pigment which appear in the final records. The cost of these materials will probably be lower than the cost of x-ray film.

Another significant fact about xeroradiography is that the xeroradiographic plates are not permanently damaged by exposure to radiation prior to their use in radiography. This might be an invaluable asset in time of atomic warfare, since ordinary x-ray films would be fogged in radioactively contaminated areas.

Fluoroscopy

In fluoroscopy, the x-ray images are viewed on fluorescing screens. The screens are modified forms of zinc-cadmium sulfide phosphors. Fluoroscopic screens, unlike film, do not enhance the contrast present in the x-ray beam itself.

Because of the limitations in brightness, contrast amplification and grain size, the contrast sensitivity and definition of fluoroscopic screens are generally appreciably poorer than those of film radiography or xeroradiography. Typical industrial fluoroscopes reliably reveal contrast sensitivities of the order of 7½ to, at best, 5%. In special test objects, the very carefully designed, extremely high-brightness rotational laboratory fluoroscopes have revealed defects of 2 to 3% contrast sensitivity. This, in general, requires extremely careful observation.

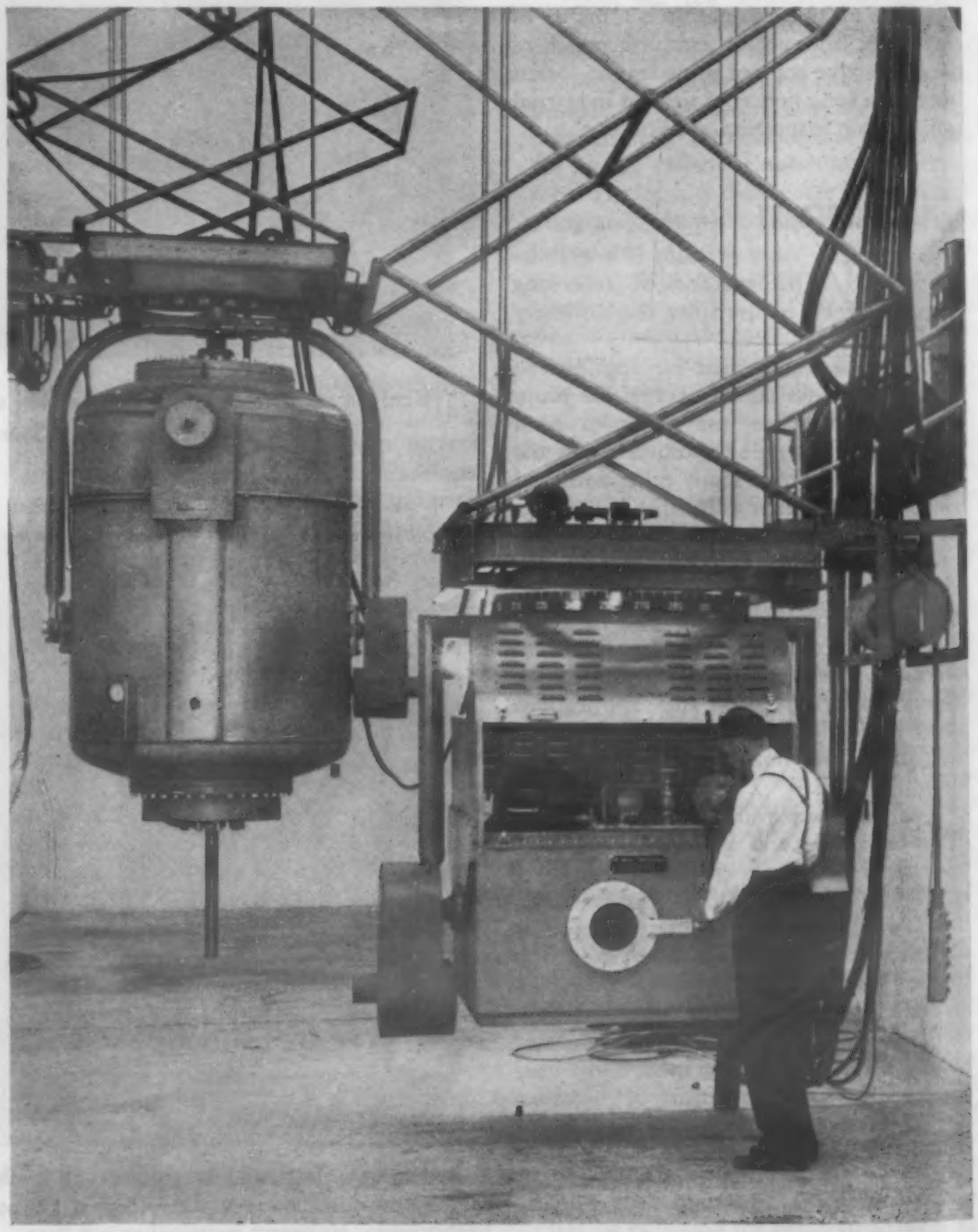
Industrial fluoroscopic inspection is ideally suited to noncritical testing of large numbers of similar units. These can be automatically conveyed past the x-ray tube and moved or rotated as desired during the time the images are being viewed on the fluoroscopic screen. The inspector views the fluoroscopic screen through a protective window of lead glass or of x-ray-absorbing, light-transparent solutions. He must be completely protected from x-rays during this process. Because the images are of relatively low brightness compared with x-ray film illuminated with high-brightness viewing lamps, the inspector must usually be "dark-adapted". This requires 10 to 30 min in a darkened room or the use of red goggles while in a brightly lighted room. He must retain the sensitive ability to see detail with low illumination. Because of the fatiguing nature of the observational task, fluoroscopic inspectors must usually be changed every 30 min. The off-duty inspector is usually employed to load test objects into the fluoroscopic inspection unit.

Fluoroscopy is well suited to production line inspection of large numbers of components for gross defects. Typical fluoroscopic units operate in the range from 80 to 150 or 250 kvp, and are primarily suited for fluoroscopic inspection of light-alloy aircraft parts, such as castings and forgings. Only relatively thin ferrous material parts can be handled by fluoroscopy. General fluoroscopic inspection reveals gross defects, such as gas porosity, casting misruns, severe dross or inclusions, and other relatively high-contrast defects. It is not suited for the revelation of microshrinkage and other metallurgical structures in most materials.

High-brightness rotational fluoroscopy, where the test object moves relative to the x-ray tube and the observer, has several advantages. Often it reveals defects which would normally be hidden by bosses and other sections of the test object in fixed-position radiography. In consequence, under properly controlled conditions, fluoroscopy can be as useful as radiography in segregating the defective units.

Fluoroscopy can be used profitably in combination with radiography. For example, in many industries at the present time, all test objects are fluoroscoped. Those with objectionable defects are rejected by fluoroscopy. This is an example in which a low-cost inspection process is

These two multi-million-volt x-ray machines at the Naval Ordnance Laboratory are capable of penetrating many inches of steel. At left is 2-million-volt equipment; at right is a 10-million-volt Betatron.



used first. The units accepted by fluoroscopy are then subjected to radiography, very often on a percentage basis. Prescreening by fluoroscopy enables acceptance of many production lots which otherwise might be rejected on a percentage radiography basis.

The extent of use of fluoroscopic inspection in American industry has not been widely recognized. However, at least one major aircraft company now uses fluoroscopy with high-brightness rotational sources for inspection of all the components of commercial aircraft suitable for x-ray inspection. Fluoroscopic inspection has also been widely used in inspection of ordnance and many assemblies.

Electronic Reproduction of X-Ray Images

At the present time, research on the possibilities of electronically reproducing x-ray images is in progress in industrial and medical laboratories. Medical fluoroscopic equipment, in which the x-ray image is reproduced on television-type image tubes, was recently demonstrated. This type of equipment could be used very profitably in industrial x-ray inspection. It has many potential advantages. It does not use film or other expensive supplies for reproducing the picture. It reproduces x-ray pictures of objects in motion. This permits scanning while rotating or moving the test object, thereby getting a three-dimensional or stereoscopic effect. The contrast and brightness of the image can be adjusted electronically. This eliminates the necessity for dark adaptation of inspectors, as required in ordinary fluoroscopic inspection. The images can be transmitted any desired distance from the x-ray equipment for interpretation. The images can be reproduced simultaneously on one or many television-type receiving units. Consequently, it would be possible to use this type of equipment to view hazardous test objects, such as explosives.

The system would also eliminate completely the chance of exposing the inspector to scattered radiation from the x-ray source. This can be extremely valuable in the case of radiography or fluoroscopy of extremely large or dense objects at very high voltages. Equipment of this type is not yet commercially available, but it can be anticipated that so splendid a development will quickly find commercial acceptance.

Electrostatic-image tubes (*e.g.*, of the type used in infrared-image tube detection) have also been employed to reproduce x-ray images. This development is not yet ready for commercial release.

Point-by-Point Inspection with Penetrating Radiation

The preceding methods of radiography and fluoroscopy were broad-beam methods. They reproduce the image of a large area or, possibly, the entire test object, while revealing detail in each local area. Supplementing these methods are those x-ray techniques which use small area detectors of x-radiation. These detectors include ionization gages, Geiger counters, semiconductor beads, and crystal counters.

In typical applications, the test objects are passed between the x-ray tube and the detecting unit on a moving belt or conveyor arrangement. As each object is located between the source and detector, the intensity of x-radiation reaching the detector is measured. The signal can then be electronically amplified, recorded or displayed, as desired. The signal reveals only the total absorption of the x-ray beam. It gives no details concerning the nature of the cause of abnormal indication.

The method was used during the last war, for example, for the inspection of 800,000 fuses to determine if one or more components had been omitted or misplaced. It is also a suitable method of measuring the total thickness of sheet materials, and has been applied in gaging strip sheet in steel-rolling mills and other industries.

Ionization gages are detection chambers filled with air, carbon tetrachloride, or other suitably ionizable vapors. A relatively high potential is applied between the electrodes of the ionization gage. When the penetrating radiation ionizes the gas present, the charged particles are collected on the electrodes and an electric current flows through the external circuit, where the current can be recorded after suitable amplification. Ionization gages have now been highly developed, and commercial gages have been constructed with a sensitivity of 0.1% of the total thickness of the object being inspected.

Geiger counters detect high-energy particles and radiation by dielectric breakdown of the gas between their electrodes. This electrical breakdown occurs because high voltage is applied to the electrode. When penetrating radiation, cosmic rays, or high-energy particles ionize some of the gas in the ionization gage, the high voltage accelerates these ions, causing further ionization by collision. A disruptive discharge then occurs and can be detected in the external circuit as a flash, "click" or count. Suitable high-speed electronic counters are employed to measure the rate of counting, which is proportional to the intensity of radiation reaching the counter. Recently developed diamond and other crystal counters show somewhat similar properties. When irradiated, they suffer periods of illumination or flash electrical conductivity which can be readily detected in external circuits.

Semiconductors, similar to those used in xeroradiographic sensitive films, can be made in the form of beads equipped with suitable leads or electrodes. In this form, they are analagous to thermistors or to certain forms of transistors and fieldistors now widely studied for use in industry. The semiconductor beads respond to penetrating radiation in such a manner as to indicate the intensity of the incident radiation by changes in resistivity.

Ultrasonic Testing

Ultrasonic sound waves (above the audible range of 20,000 cycles per sec) have characteristics which make them very useful for materials inspection. Their short waves are reflected from small flaws. Audible sound with long wave lengths flows around and past flaws without appreciable directional reflection. Another useful property of high-frequency, short-wave length sound is its ability to travel in a straight line with a searchlight effect, instead of scattering and bending around corners, as does audible sound. Further, ultrasonic waves are able to penetrate thicker sections of material, such as steel and aluminum. Because of these properties, it is possible to use ultrasonic waves to examine the interior of thick materials and locate accurately any discontinuities present.

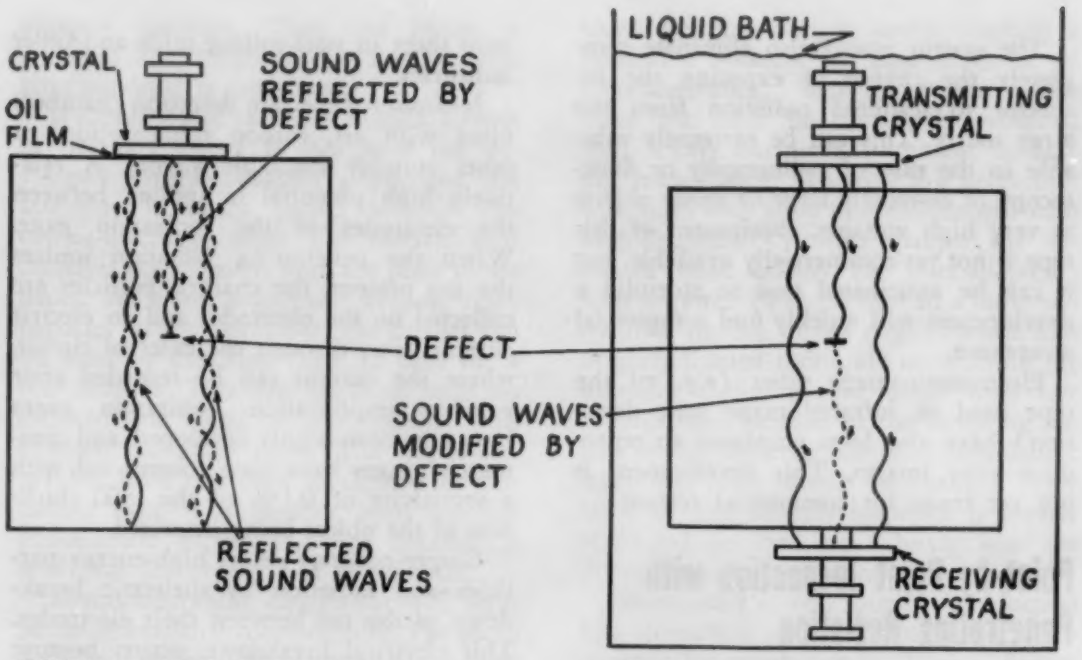
Three basic methods have been developed for utilizing ultrasonic energy for the inspection of materials. In the order they will be discussed here, they are the reflection method, the through-transmission method, and the resonant-frequency method.

Reflection Method

It is a well-established fact that materials such as metals, plastics and liquids transmit sound better than air. When ultrasonic waves are transmitted through a piece of material and hit the boundary between solid and air, the waves are practically stopped and reflected back toward their point of origin. Also, if a discontinuity (void) exists in the material, it will reflect the portion of the beam hitting it.

This reflection or echo principle is used in the ultrasonic Reflectoscope. Ultrasonic waves are transmitted into the materials, and the time interval required for the vibrations to penetrate the material, reflect from the opposite side or from the internal discontinuity, and return to the point of origin is measured.

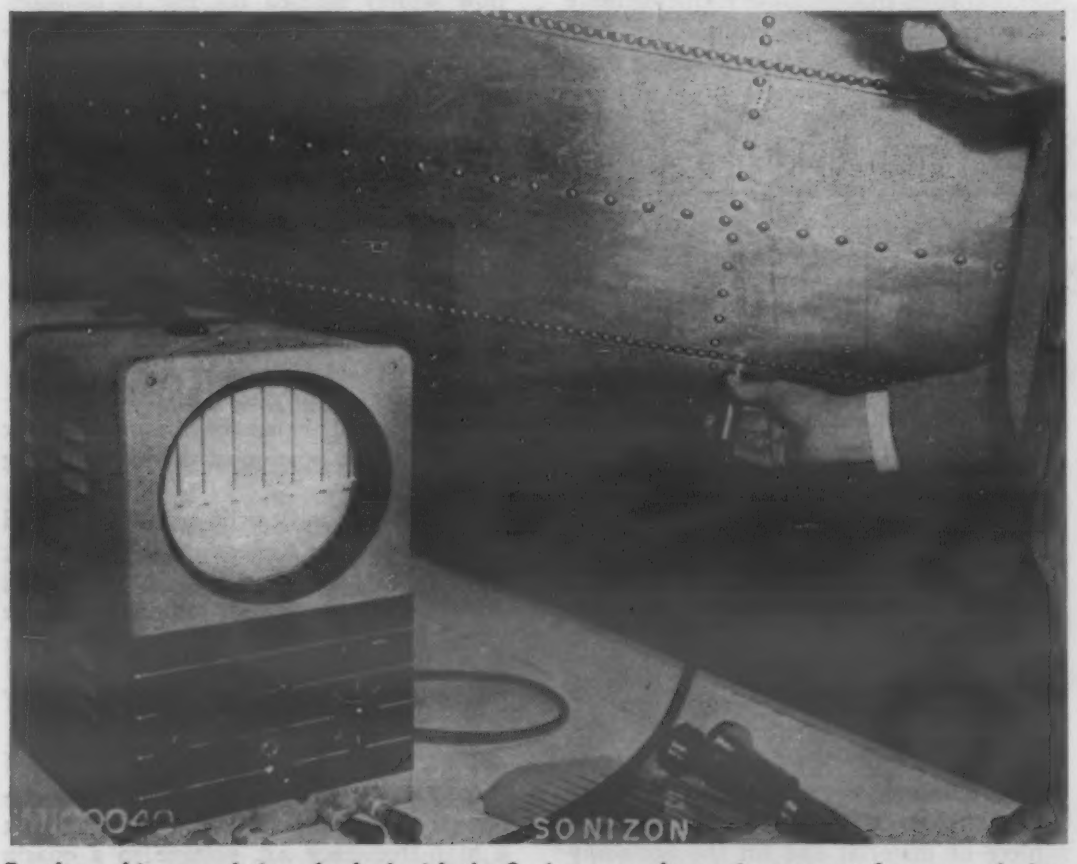
Basically, the Reflectoscope consists of three essential parts. An electronic generator creates ultrasonic waves by supplying a high-frequency a.c. voltage to a quartz crystal. The crystal radiates these waves into the material and also acts as a re-



REFLECTION METHOD — THROUGH-TRANSMISSION METHOD

Schematic sketch of reflection and through-transmission methods of ultrasonic inspection.

Reflectoscope in use. Note indication of defect on cathode-ray oscilloscope. (Courtesy Sperry Products, Inc.)



Fuselage skin gage being checked with the Sonizon, an ultrasonic resonant-frequency device. (Courtesy Magnaflux Corp. and Douglas Aircraft Co.)

ceiver and detects back reflections. An electronic amplifier applies the reflected signal to a cathode-ray oscilloscope, which measures the time interval between transmission of the outgoing and reception of the incoming waves. A typical screen pattern will show two peaks, one representing the initial pulse or surface of the material, and the other representing the reflection from the other side. A discontinuity will result in a "pip" occurring between the two peaks. A calibrated square wave can be superimposed on the screen to locate the discontinuity accurately.

The quartz-crystal searching units come in a variety of useful sizes and frequencies. The nature of the material, types of defects being investigated, and the size of the test specimen determine the size and frequency to be used. The crystals range in size from ½ in. square to 2 in. round, and come in standard frequencies of ½, 1, 2¼ and 5 megacycles. Since the flat-type crystal searching units are principally effective for regularly shaped parts of thicknesses in excess of ½ in., angle-beam searching units have recently been developed. The angle-beam unit is used for testing parts with a thickness of less than ⅝ in. and areas not accessible for testing with the standard (flat) searching unit, such as welds, tapered blades, fan or turbine blade-roots, high pressure steam piping and irregularly shaped sections.

The ultrasonic beam from an angle searching unit can be compared to a beam of light traveling through space and being reflected from a number of mirrors. The path traveled and whether or not the beam returns to its source depend on the angles at which it impinges upon the reflecting surfaces, as well as the number and location of these surfaces. Therefore, it is necessary to scan the surface of the piece or part in a geometrical pattern to assure receiving a reflection from any discontinuity present.

In this type of inspection, it is extremely important to obtain proper coupling between the crystal probe and the work. A smooth surface, equivalent to that obtained with a portable disk sander, is necessary. The actual coupling is accomplished with any one of several fluids which will give intimate contact between the crystal and the test surface. Various light machine oils in the range SAE 10 to 30 can be used, as well as transformer oil and glycerine used with a wetting agent. In Europe, some work has been done using a "turgid" membrane filled with water and attached to the crystal, as a means for establishing intimate contact on rough and irregular surfaces.

Most metals can be inspected by the reflection method. The depth of penetration achieved in a given material depends chiefly on grain size and method of forming used during manufacture and fabrication. Coarse-grained materials like copper and lead are more difficult to penetrate than steel and aluminum. Forged and wrought products are easier to penetrate than castings. Present models are designed to penetrate 30 ft of aluminum and steel. This figure is approximate, since the

depths of penetration in two pieces of a particular material may not be exactly the same. They are not necessarily the final limit, nor do they indicate penetration that can always be achieved. The reflection method is generally not good for thicknesses below ½ in. This is because the transmitted pulse covers the first ½ in. or so on the oscilloscope, and thus hides any flaw indications in that area.

The reflection method will locate internal discontinuities which present a reflecting surface to the sound beam as it passes through the material. The minimum size discontinuity which can be detected is roughly one having a projected lateral dimension equal to about 0.1% of the distance from the crystal to the defect. For example, at 6 in., the smallest detectable defect would be 0.006 in.; while at 10 ft, it is possible to locate a ⅛-in. defect, with an accuracy of upward of ⅛ in. By moving the crystal on the surface, the extent of the discontinuity can be outlined.

The size of the discontinuity reflection on the oscilloscope depends on the proportion of transmitted sound waves reflected by the discontinuity area perpendicular to the ultrasonic beam. A trained operator can usually determine the type of defect after scanning the sweep-line indications. With training, an operator can readily distinguish between acceptable and rejectable material. This is done by first establishing the tolerance standards; the sensitivity of the instrument is then adjusted so that only those discontinuities equal to or greater than tolerance will be indicated by the oscilloscope.

The reflection method has already been widely used for the inspection of billets; blooms; forgings, such as steel axles, rotor blanks, tool and die stock; and extrusions. Where the weld face is smooth, this method can detect hair-line cracks and fusion-line flaws. The equipment is quite portable and lends itself readily to plant trouble-shooting jobs.

Through-Transmission Method

When a beam of sound energy is directed through material, some of the energy is dissipated in going through the material. If a discontinuity is also encountered, additional energy is absorbed. Thus, differences greater than the normal losses between the energy of a sound wave entering one side of the material and that picked up on the other side indicate the presence of discontinuities in the specimen. This is the principle of the through-transmission method used in the Hypersonic Analyzer. Basically, the equipment consists of the following essential parts: (1) An electronic ultrasonic generator for creating a signal of 50 to 100 kc. (2) A piezoelectric crystal transducer that converts the ultrasonic signal into mechanical ultrasonic energy, which is transmitted through the test piece. (3) A piezoelectric crystal transducer which serves as a receiver of the transmitted sound and converts the mechanical energy into an electrical signal. (4) An electronic amplifier which increases the output of the receiving transducer. (5) An indicating device for signaling the presence of discontinuities.

In operation, the frequency is adjusted for the particular type of material being tested. A critical set of radiation frequencies is selected so that the resultant ultrasonic beams through the material are highly modified by any discontinuities present.

Since fluids such as water and oil give better coupling than air, they are generally used as the transmitting medium between the transmitter, material and receiver. In some applications, air or other gasses can be used, the choice depending upon the material, and whether or not it can be exposed to a particular fluid medium without damage.

To operate the instrument, the test piece is placed in the coupling medium, the transmitter is energized, and sends ultrasonic waves through the material. These waves are picked up by the receiving crystal on the opposite side, transformed to electrical energy, and amplified. A constant signal level is registered until discontinuities are encountered. The detection of discontinuities can be indicated by a meter or any signaling device desired.

Depending on the area to be inspected, one or more transmitting and receiving crystals can be used. In some cases, six-channel units have been designed to inspect a wide area. Since the transmitting and receiving crystals must be kept parallel and opposite each other, the transducers remain stationary, and the material to be inspected is moved between them. Automatic set-ups can be made in which the material is run through at a high speed, and a signaling arrangement, such as a light, bell or marking device, is employed to indicate when defects are encountered.

Most metallic materials and plastics can be inspected by the through-transmission method. Present equipment is capable of examining thicknesses up to 5 in. and down to 0.001 in. The piece being inspected must have a uniform cross section over the area covered by the crystals, so that the sound beam goes through the same thickness of material at all points. The pieces being inspected must also have axial continuity; *i.e.*, the same cross-sectional thickness must be presented to the crystals as the material is run through for inspection. Thus, the method is most applicable to shapes having a constant cross section, such as those obtained by rolling and extruding.

The surface finish necessary for satisfactory inspection depends, to a large extent, on whether or not a liquid bath is used as a coupling medium. If a liquid bath is used, the surface need only be the equivalent to a machined or sawed surface. When the crystals make direct contact, using only a thin film of oil as a couplant, the surface must be much smoother.

The through-transmission method detects discontinuities associated with two physical properties of the material: a change in density or mass, and a change in modulus of elasticity or stiffness. The method does not tell which property is changed, but indicates that either one or both have changed.

The minimum change in density which can be detected practically is a 0.001-in. internal air film. A 2% change in modulus of elasticity can also be detected. Because of its sensitivity to changes in modulus of elasticity, very thin slits or cracks can be detected by this method. In this type of flaw, the change in total mass is negligible, but at the separation, the effective modulus is obviously small, since the material is air. The method will detect flaws of this type as small as 0.001 in. This type of flaw occurs frequently in sheet materials, usually as laminations. Separations in sandwich-type construction of sheet materials at the bond is another example of this type of flaw. All other common types of gross defects conforming to the above rules, such as porosity, inclusions, segregations and shrinkage voids, can be picked up.

Since the penetrating beam is sensitive to many types of discontinuities, it is not possible to tell what type defect is present when an indication is obtained. Generally the Hypersonic Analyzer is used on jobs involving a specific type of defect. And, as previously mentioned, a critical set of radiation frequencies and electroacoustic designs are selected so that the ultrasonic beam is affected by this type of discontinuity.

From the above, it is apparent that the through-transmission method of ultrasonic inspection is most applicable in the inspection of continuous production lines of material with a uniform cross section. Typical applications are inspection of products produced by rolling and extrusion, such as metal sheets and strip, and plastic products. The method has wide application in manufacturing processes where bonding of materials is employed, such as safety glass, tire plies, bonded metal strips, clad metals, and sandwich plastic materials.

Another advantage of production set-ups is its high rate of inspection. Since high sound frequencies are used, the

The Metroscope operates on the ultrasonic resonant-frequency principle and is used for material thickness measurements. (Courtesy J. W. Dice Co.)

relay action is fast and material can flow through. For example, sheet steel can be inspected at 2600 ft per min. While the through-transmission method is essentially a qualitative inspection, development work is still in progress, and it is probable that many refinements will result in the future.

Resonant-Frequency Method

There are now several resonant-frequency ultrasonic instruments on the market. The majority of these are used for thickness measurement. These instruments operate on the resonant-frequency principle. Basically, they consist of a simple electronic oscillator supplying voltage at ultrasonic frequencies to a piezoelectric crystal. The crystal probe is pressed into oil contact with the part to be tested and induces longitudinal vibrations in the test piece under the area of contact of the crystal. The rotation of a motor-driven tuning condenser continuously sweeps the frequency of the oscillator through its tuning range. Simultaneously, the beam of a cathode-ray tube is swept horizontally across the screen, once for every revolution of the condenser. When the test piece has resonant frequencies within the tuning range, there are, as the condenser tunes through these frequencies, momentary increases in the energy drawn by the crystal. Each increase in energy drawn by the crystal is indicated by a vertical deflection of the cathode-ray beam. Therefore, the resonant frequencies of the test piece are denoted by the positions of vertical peaks along the horizontal trace. Most metals have low ultrasonic absorption; consequently, sharp resonance peaks are obtainable.

Accordingly, a thickness indication is obtained corresponding to the ultrasonic frequency which is resonant through the test piece. A series of changeable scales are laid out to read directly in thickness for the material (steel, aluminum, etc.) under test.

The accuracy of this type instrument is within 2% over a long period of use, and is within 1% when a readjustment of calibration is made each day. Convenient controls enable the operator to make this setting easily.

There is a practical upper limit to the thickness that can be measured by the fundamental mode method. As thickness of the test piece increases, the ultrasonic wave length required for resonance likewise increases. Therefore, the diameter of the crystal must be increased to avoid excessive spreading of the ultrasonic waves and consequent loss in sensitivity. Also, with thicker test pieces, the thickness of the crystal must also be increased to keep its resonant frequency close to the tuning range of the instrument. For these reasons, the fundamental mode method is used only with thicknesses of less than 0.400 in. of steel, depending on contact conditions.

Above this limit, harmonic modes are used. To read thicknesses up to 4 in., readings of two of the many harmonic peaks are taken, and the thicknesses can be quickly calculated using a convenient formula.

These instruments will operate on any material of moderately good sound-conducting characteristics. Sound-absorbent materials, such as paper and wood, cannot be tested. The scales of these instruments are generally calibrated for steel, but scales can be furnished for other materials. However, any scale can be used merely by multiplying the ratio of sound speed in the material for which the scale is calibrated to the speed of sound in the material under test.

While best results are obtained with moderately smooth surfaces, such as rough machined or good cast faces, these instruments give surprisingly excellent results on many rough or scaly surfaces, such as the scale on hot-rolled or pierced tubing.

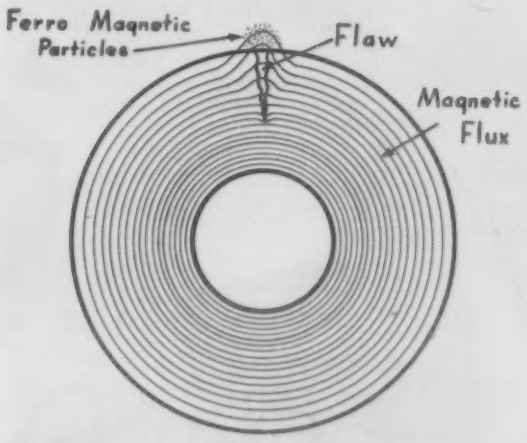
These instruments can also be used for flaw detection. A harmonic pattern is established on the screen using a sound test piece. Then, the reduction of the pattern is noted as the probe passes over a defect (such as a lamination) which causes dispersion of the ultrasonic energy.

Resonant-frequency instruments have gained rather wide-spread use in measuring wall thickness where only one side is accessible. They are used also in testing for lack of bond on metal-backed bearing materials, and for detection of flaws parallel to the surface in sheet stock in a wide variety of industries.

A special portable instrument for detecting cracks across the webs of railroad rails within joint-bar limits has been developed along with a companion instrument, capable of measuring a range of thicknesses of steel from 1/16 in. to 12 in. This instrument has gained extensive use in determining the extent of corrosion in refinery and chemical-plant equipment. Many plants are using this instrument to obtain complete data on corrosion rates and over-all conditions of plant equipment. Periodic surveys have helped appreciably in preparing preventive maintenance schedules.

In the sonic range, an instrument has been developed for mechanically vibrating the test piece in a frequency range of 100 to 10,000 cycles. In operation, the test piece is excited by an electromagnetically driven stylus from a calibrated variable-frequency oscillator. Resonance between the test piece and the stylus is detected by a cathode-ray oscilloscope through a wide-range microphone. The instrument has been successfully applied to the inspection and grading of grinding wheels, and can be used on a wide variety of materials, such as refractories, ceramics, sintered metals, metals and plastics.

Magnetic Particle Testing



Schematic sketch shows basic principles of magnetic particle inspection. So-called leakage fields caused by flaws attract and hold iron filings and thus indicate location of flaws.

Principles of Operation

In this country, the name "Magnaflux" is synonymous with magnetic particle testing. The magnetic particle method depends for its operation on basic magnetic principles. If a crack, or other crack-like discontinuity in a magnetized piece of ferromagnetic material, is so located as to be transverse to the direction of the magnetic field in the material, that field is distorted. The flux lines are crowded or deflected around the ends of such a magnetic obstruction. If the obstruction lies near enough to the surface of the material, some of these flux lines will be crowded outside the surface of the material, and a "leakage field" is produced at the surface over the discontinuity. The closer the discontinuity is to the surface, the stronger the leakage field, and, in the case of a surface crack, the field is quite strong and highly localized.

If a powder of fine particles of a magnetic material, either dry or suspended in a liquid, is applied over the surface in the vicinity of a leakage field, some of the powder will be attracted and held by the leakage field and will set up a magnetically-held pattern outlining the discontinuity.

The greater the obstruction in the magnetic path, the stronger the leakage field. Sharp, deep cracks at right angles to the surface give the strongest patterns; and large discontinuities below the surface, having their principal dimension at 90 deg to the surface, are the most favorable conditions for producing strong surface indications. Small defects, or defects of

unfavorable shape, must be close to the surface to be found. Surface scratches and tool marks produce indications only at high levels of magnetization.

From the above, two fundamental points are apparent:

1. Given a part containing discontinuities, it is necessary, in order to produce good leakage fields, to magnetize the part in such a way that the resulting field will cross the discontinuities.

2. The strength of the leakage field, and hence the strength of the powder pattern produced, will vary with the intensity of the magnetization set up in the part.

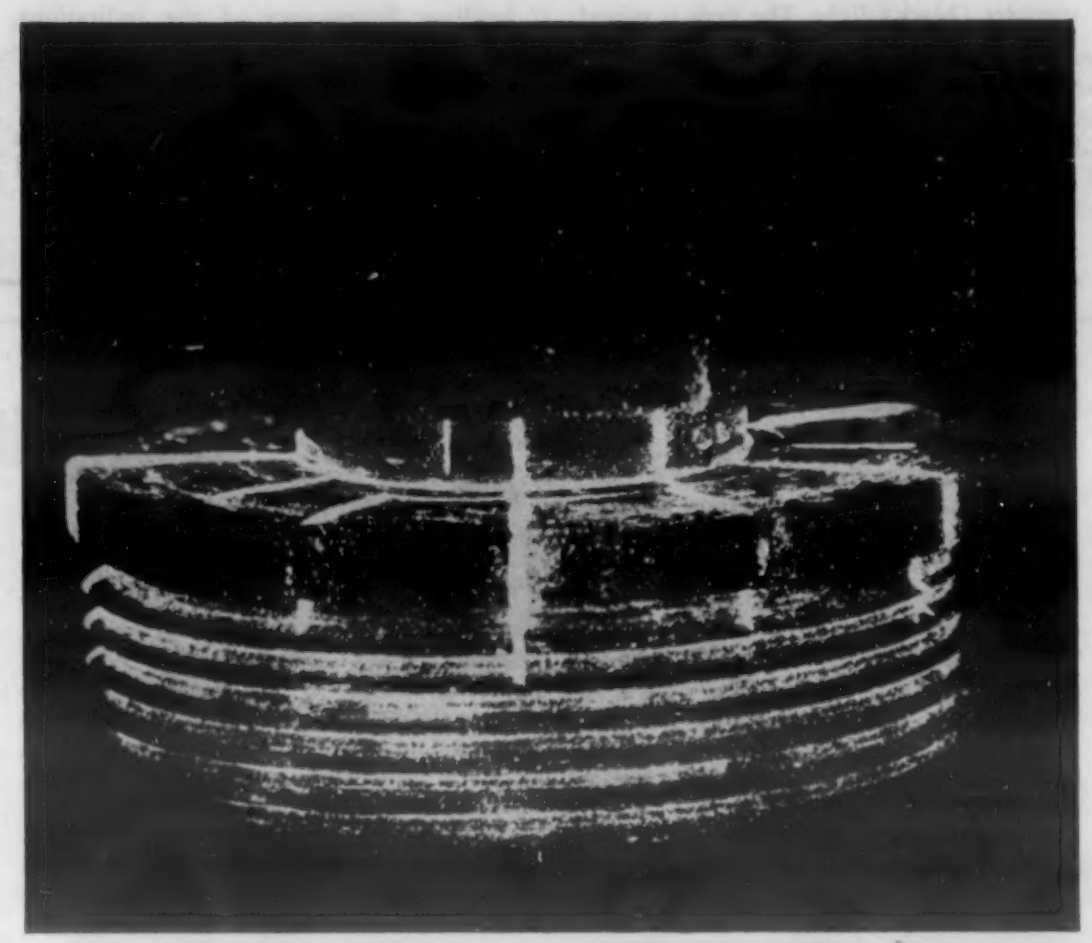
It is easy to see that magnetizing methods must be understood, since use of the wrong method may make the inspection unproductive. Also, any variations in technique which affect the strength of the leakage fields will greatly affect the results obtained.

The possibilities of varying the sensitivity of the method are numerous and complex. Obviously, the stronger the magnetizing current, the stronger the field. Because of the behavior of ferromagnetic materials, stronger fields always exist while the magnetizing current is flowing than after it is cut off. Therefore, high sensitivity is obtained by applying the powder or suspension simultaneously with the magnetizing current—the "continuous" method. The "residual" method, assuming the same applied magnetizing current, but with the powder or suspension applied after the current is shut off, is relatively less sensitive. In addition, the strength of the residual field is affected by chemical composition and heat treatment (hardness).

Choice of magnetizing current also affects sensitivity. A.c., because of skin effect, magnetizes the surface layers of the material more strongly than those deeper in the part. D.c. gives a more uniform field intensity over the entire cross section. Thus, if the inspection is for surface cracks only, a.c. gives maximum sensitivity, while d.c. gives greatest sensitivity for the location of subsurface discontinuities.

For purposes of magnetic particle inspection, rectified a.c. gives the same results as d.c. and is considered comparable to straight d.c. Surge characteristics available in rectified a.c. equipment especially designed for this type of testing and in some motor-generator sets are advantageous in that discontinuities can be located at a greater depth below the surface than with equipment which does not have surge characteristics. For the location of subsurface defects, the best magnetizing procedure is to use single-phase, half-wave rectified current. This current combines the advantages of surge characteristics due to the wave form with additional particle mobility due to the pulsating current.

A recent development, called "Duovec", enables parts to be subjected to multidirectional magnetization at one shot. One application of particles, followed by one visual inspection, reveals defects in any direction. Actually, the magnetic field is rapidly shifted in direction by combinations of magnetizing currents. This method has resulted in tremendous savings of time and labor on parts requiring multidirectional inspection.



Magnaglo indications of cracks in gun breech part. (Courtesy Magnaflux Corp.)

Equipment

The basic equipment for magnetic particle inspection is relatively simple. It includes convenient facilities for setting up suitable fields of proper strengths and in the correct directions. Means are provided for adjusting the amount of current flowing, and an ammeter, plainly visible to the inspector, should be provided in the magnetizing circuit so that the inspector can assume that the correct magnetizing force has been applied for each inspection. Facilities are needed for the correct application of the inspection medium. In some cases, it may also be necessary to provide facilities for demagnetizing after inspection. Special semi-automatic or automatic equipment can be used for more rapid and economical inspection of parts on a production basis.

Inspection Medium

Inspection material is available in various forms and colors. The type of defect to be located and the surface being inspected are determining factors in selecting the best material.

Dry Method—The materials normally used for this method are finely divided ferromagnetic particles in powder form. The particles are coated to afford greater particle mobility. They are also colored to afford maximum contrast with the part being inspected and are available in gray, black and red. The dry method is easier to use on rough surfaces and is more readily portable. Dry particles are also more sensitive for the location of large subsurface discontinuities. The powder is usually applied with some sort of hand applicator or by a special gun. The powder should be applied in the form of a low-velocity cloud, so that the particles will have an opportunity to line up in indicating patterns as they approach the surface of the magnetized part. Excess powder can be removed by a low-velocity air stream, regulated to just remove excess powder without disturbing lightly held powder indications.

Wet Method—The ferromagnetic particles used in the wet method are smaller than those in the dry method. The material is furnished in paste form, which is mixed with a light oil, such as highly refined kerosene, in the ratio of approximately 1½ oz of paste to 1 gal oil. The bath must be properly agitated in order to prevent the indicating material from settling out. The inspection medium is flowed or sprayed over the surface, or else the part is immersed in the suspension. The wet method is generally used on smaller parts and those having smooth or machined surfaces. It is somewhat more sensitive than the dry method for indicating extremely fine defects, due to the smaller particle size. The paste is available in either red or black.

Magnaglo—This method is deserving of special mention. Application is by the wet method, but the inspection medium is a specially developed paste in which the ferromagnetic particles are coated with a dye which fluoresces brilliantly under ul-

traviolet (black) light. The bath is mixed in the same way as the red or black paste, except that only 0.1 to 0.2 oz of paste is used per gallon of suspension. The indications must be viewed under black light in a dark or shaded area. Because of the brilliant fluorescence of the indications, this method is highly sensitive in indicating very fine or small discontinuities. It is also excellent for more rapidly inspecting irregular or dark surfaces which cannot be clearly lighted or viewed straightaway, such as springs and the interior of tubes, borings, etc. Magnaglo, like Magnaflux, is applicable only to ferromagnetic materials. It should not be confused with fluorescent penetrant inspection, as discussed in detail in the next section.

Penetrant Methods

Perhaps one of the oldest forms of nondestructive testing is the penetrant method, in which a penetrating liquid is used in conjunction with a suitable developer, to reveal surface discontinuities. The method in its simplest form is the old "oil-and-whiting" method. The penetrant method is a very useful nondestructive test for revealing surface cracks, pores, leaks, and similar discontinuities in nonmagnetic material where magnetic-particle inspection cannot be used.

Dye penetrant method being used to check an aircraft landing gear part. Fine, wavy line near center of photo indicates a crack. (Courtesy Dy-Chek Co.)

Fluorescent penetrant method reveals crack in weldment under black light. (Courtesy Magnaflux Corp.)

Zyglo

One of the best known forms of this type of nondestructive test is Zyglo, a fluorescent penetrant inspection which utilizes black light (near-ultraviolet light) for the detection of defects. Although generally used to reveal surface discontinuities of nonmagnetic materials, it is also adaptable to magnetic materials such as ball bearings, where magnetism and handling are major problems.

Basically, fluorescent penetrant inspection makes use of a water-washable penetrant of high fluorescence and unusual wetting or penetrating properties. Because of its low surface tension, it will readily be drawn into extremely small surface openings by capillary action. It carries in solution a dye which will fluoresce brilliantly, even in minute quantities, when exposed to black light.

The technique of Zyglo consists first of applying a surface film of penetrant to the areas being inspected, by dipping, brushing or spraying. Dipping is the most convenient for small- and medium-sized parts. After dipping, the excess penetrant is drained off during a time interval required for the penetration of the discontinuities. This interval varies from a minute or so to several hours, depending on the nature of the defects to be located, but is usually from 5 to 15 min. The next step is rinsing; this is best accomplished by a special low-pressure water spray. It can also be accomplished with water-soaked rags or by sand blasting. Solvents should not be used, as they may remove indications of discontinuities. Rinsing should be done, if possible, under black light to insure a rapid and complete operation. Parts can be dried after the rinse by wiping, use of a hot-air oven, or an air blower.

After rinsing and drying, the indications can be developed by either the dry or the wet method. In the dry method, the parts are dusted with a developing powder, which helps draw the penetrant out of the flaws by capillary action, thereby intensifying the indications and rendering them more brilliant. Before inspection under black light, a developing time of at least half the penetrating time should be allowed. In wet developing, the developer is applied to the surface in the form of a colloidal water suspension. This is done after rinsing and before drying. It can be applied by either dipping or spraying. After drying, the result is a uniform layer of developer on the surface, which increases the brilliance of, and contrast with, the indication. After the inspection, the developer can be removed by a simple water wash.

The actual inspection is conducted under a fixed or portable black light with all other lights subdued, such as in a booth or shaded area in the plant. The indications fluoresce brilliantly, and a deep discontinuity can be distinguished from a shallow one by the width or amount of bleeding of the fluorescent indication. Zyglo equipment can be extremely portable for universal use, or can be secured in special-purpose, semi-automatic or automatic equipment.

Partek

A recently introduced method is Partek, or "filtered particle inspection". This method depends on the unequal absorption into a porous surface of a liquid containing fine particles in suspension. It is very effective for locating invisible cracks in unfired ceramic materials which often open up before firing. The general technique is quite simple: the test object is dipped into, or sprayed with, a liquid having fine particles suspended in it. Since the surfaces of porous materials will absorb liquids with which they are wet, a defect will, in turn, absorb more liquid because of its depth. This preferential absorption causes the fine particles in the solution to be carried to the area of the defect, filtered out at the surface, and concentrated directly over the crack, causing a visual indication.

Partek indications are readily visible under white light, and the inspection can be rapid and automatic, carried out on conveyors at relatively high rates of speed. Although the colored particles clearly mark the discontinuity, it is sometimes desirable to increase speed and visibility; in these cases, Partiglo is recommended. Partiglo makes use of fluorescent particles, with inspection carried out under black light. Partiglo indications mark the discontinuity with a glowing line of color. All Partek and Partiglo indications fire off completely in the kiln.

Dy-Chek

A newcomer to the penetrant field is Dy-Chek, a dye penetrant. Dy-Chek indicates surface discontinuities or surface openings on metal parts by bright red lines or dots on a white background.

The process involves the use of three

noncorrosive liquids. First, the surface-cleaner solution is used to prepare the surface for inspection. The next step is to apply the penetrant by brush, spray or dipping. The part should be allowed to stand for at least 5 min. For very small discontinuities, such as grinding checks, the penetrant solution should be applied three times with a 5-min penetration time after each application. After standing, the penetrant is removed with the cleaner solution. The developer is applied then by brushing or spraying. As the developer dries, the dye penetrant, which has remained in the discontinuity, will be drawn to the surface by the developer, resulting in bright red indications.

Dy-Chek should not be used at a temperature of less than 70 F. For maximum sensitivity to very small flaws, the parts should be warmed to 100 to 150 F. Like the other penetrant methods, Dy-Chek has found extensive use in critical aircraft-component inspection applications.

Electromagnetic-Induction Tests

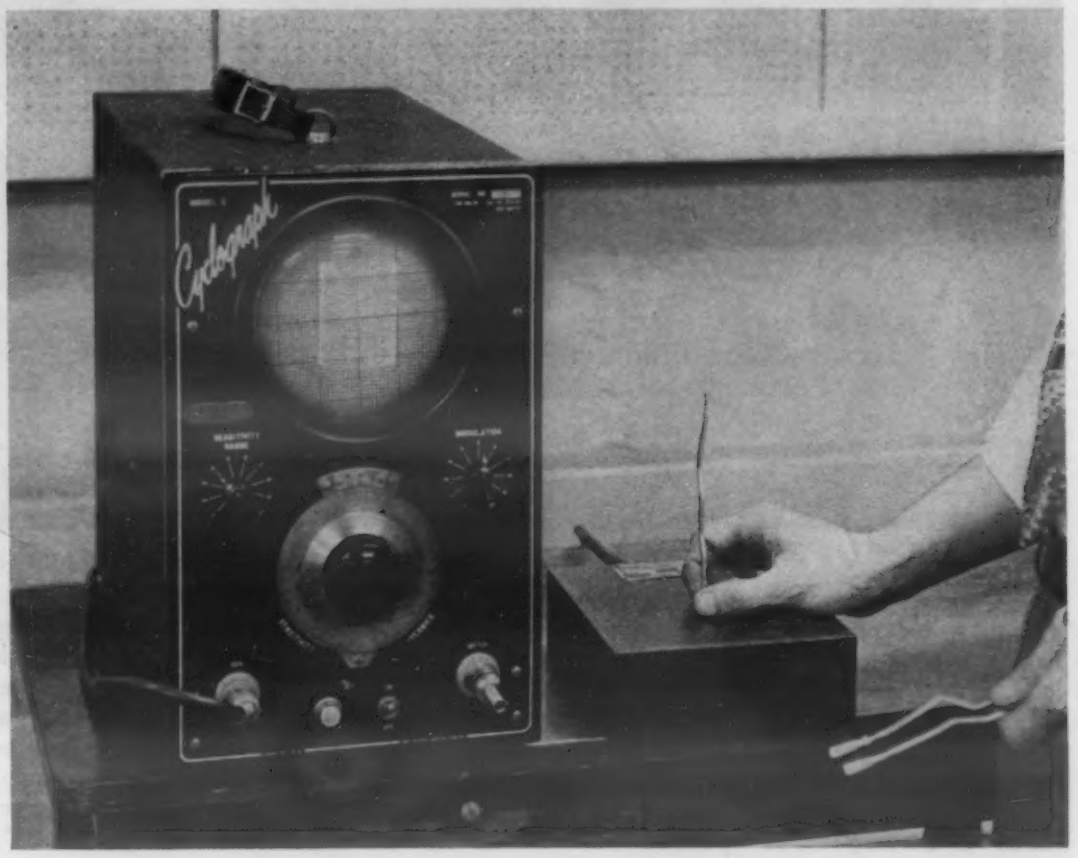
Large numbers of electromagnetic-induction testing methods have been developed and patented. However, relatively few have survived in large-scale production inspection use because electromagnetic-induction tests must be engineered for each specific application. The electromagnetic fields must be coupled properly with the test object in order to reveal the defects within the object. Each different size of test object usually requires a different test coil.

Electromagnetic-induction tests involve the induction of varying electrical currents in the test objects by means of repeated variations in electromagnetic field. In ferromagnetic materials, the alternating magnetic field in the test object also influences the indication. The induced current in the test object produces differences in electric potential, magnetic fields, and heat or temperature gradients. When alternating or varying currents are induced in ferromagnetic materials, heat is produced not only by ohmic losses proportional to the square of the current density, but also by hysteresis losses in the magnetic material.

The presence of defects or discontinuities in the test object can be revealed by any of several detection methods. Many of the devices respond to the changes in input power in the exciting coil, as the internal losses in the test object change in response to defects. Many other electromagnetic-induction testing units employ separate pickup coils which measure the electromagnetic fields around the test object somewhat independently of the magnetizing current in the exciting coil. Most commercial units of this type now employ balanced pickup coils. These are arranged so that the normal variations in properties of the test objects are cancelled out. Only the discontinuities are revealed by external signals.

Efforts have been made to apply electrical contact probes to pick up the signals due to any current flow in the test object. These, in general, have not been widely successful because of the difficulties of keeping the surfaces of the test objects sufficiently clean to make good electrical contacts, and because of the difficulties of preventing the induction of signals in the pickup circuit due to the exciting coil.

The pickup devices can be used to detect variations in the electrical potential distribution, in magnetic field strength, in high-frequency electromagnetic wave properties, in temperature, in mechanical force or torque, in losses in the material of the test objects, or in combination of these factors.



Electromagnetic-induction testing devices can be used for a wide variety of applications. Here one type of equipment is being used as a manual metal sorter. (Courtesy J. W. Dice Co.)

Although electromagnetic - induction nondestructive testing devices have been developed to a very high degree of sensitivity, they respond primarily to changes in the *volume properties* of the test object rather than to reflection from defects. The defect will be readily detected if it changes the over-all resistance to the eddy-current flow, or the over-all magnetic permeability of that volume of the test object included in the measurement. The electrical output signals do not necessarily discriminate between various types of flaws in the test object. Skilled interpretation is sometimes necessary to correlate the signals to the nature of the defects which cause them.

At the present time, the successful commercial applications of electromagnetic-induction nondestructive tests are chiefly in the fields of sorting parts of similar size and geometry, and the inspection of long rolled or extruded shapes, such as rods, tubes and pipes, whose cross section is constant. Electromagnetic-induction type tests offer many advantages for this type of inspection. They are rapid and can be made completely automatic. Indications can be recorded electrically, identified by visual or audible signals to an inspector, or marked directly on the defective unit. Under these conditions, the cost of electromagnetic-induction testing may be much lower than that of most of the other methods of nondestructive testing which require the continuous attention of a skilled inspector and manual handling of the parts.

At present, electromagnetic-induction nondestructive tests are used for the nondestructive testing of steel tubes and bars; for the testing of railway-car wheels and axles for surface cracks; for the testing of welds, particularly longitudinal seam welds in pipe or tubes; for flaw detection in nonmagnetic metals to detect internal seams and laps in sheet, tubes and bars; for the salvaging of railroad rails and other steel parts; for the sorting of machined parts and materials; for measuring stress and predicting fatigue damage in

An electromagnetic-induction device used to sort and classify steel bars. (Courtesy Fisher Scientific Co.)

materials; for precision comparators and gaging applications; for the inspection of lead cable sheath and mine hoist cable; for the measurement of the thickness of nonmetallic coatings on metallic bases and the thickness of metallic coatings on nonmetallic bases; for the inspection of boiler tubes; for the detection of superficial cracks in wires; and for other applications. It should be recognized, however, that engineering development is usually required before new applications are made practical for electromagnetic-induction testing.

Magnetic Analysis Methods

The original magnetic analysis methods have been considerably improved and extended over about the past 25 years. An extensive line of equipment is available for the inspection of tube and bar stock in steel mills and similar applications, and can be specially engineered for each application as desired. It includes automatic handling equipment for passing the tubes or bars through the induction and detection-head units. Very sensitive discrimination circuits, operating on a variety of principles and subjecting the signals to repeated tests and checks, have been developed for commercial units. These units indicate the presence of defects or discontinuities by visual or audible signals, by marking the test objects, or by external records, as desired. Many of these units have been in successful continuous service testing bars and tubes in steel mills for periods of a decade or more.

Other forms of magnetic-induction tests have been developed for inspection of lead sheath on telephone cable, for the testing of railroad rails, and for the inspection of aircraft propeller blades. Specialized forms of electromagnetic-induction tests such as these have been used in particular applications but have not been made commercially available to industry on a large scale.

The number of other fine developments in the field of electromagnetic-induction nondestructive testing are too great to be included in detail in this summary. The method has been proved under production conditions as a reliable means of detecting seams and laps in rolled and pierced steel tubing. It is quite sensitive to subsurface cracks in steel tubes and bars, and responds to many defects which lie so deep within the material as to be difficult to reveal by magnetic-particle inspection. Slivers and cupping in hardened steel bars have been detected reliably, as have inclusions, inadequate penetration, and other defects in seam-welded steel tubes.

The method is also responsive to production errors, such as gross changes in geometry of the part, broken mandrels and other materials left in tubing, internal segregations, and other defects. Magnetic analysis indications usually respond also to differences in heat treatment, hardness, shape, structure, strain and stress within the steel. Incipient burns, weak welds and leakers are detected in welded tubing. Materials of different chemical compositions can be readily sorted and detected. These are but a few of the many possible applications of magnetic-analysis nondestructive test methods in industry.

Cyclograph Method

In the Cyclograph technique of nondestructive testing, the test object is placed within a single search or detection coil. This coil is supplied with high-frequency alternating current from a suitable oscillator. The rapidly varying electromagnetic field induces eddy currents and varying magnetic fields within the test object. The total losses, both electrical and magnetic, within the test object serve to load and to partially detune the oscillator. The amplitude of the oscillation is recorded on a cathode-ray oscilloscope. The Cyclograph, in this form, is primarily applicable to the rapid sorting of test objects of similar geometry, such as bolts and machined parts.

The Cyclograph has been applied successfully to the inspection of automatic machine-welded tubing where the tubing is subjected to controlled conditions of welding and tooling. Under these conditions, it responds to the stress in the weld and in the tube, to the chemical analysis of the tube, to the structure of the weld and tube, and, of course, to the mass of metal in the weld and the tube.

The Cyclograph has also been used successfully to detect damage to mine hoist cables, and to tubes, bars, and other structures subjected to dynamic or repetitive loads which produce fatigue damage and failure. It has also been applied successfully to the measurement of stresses in steel parts, including stresses due to applied loads, as well as stresses arising from cold working and quenching.

The Cyclograph is not sensitive to any type of crack, flaw or defect whatever, save where the presence of these defects significantly influences the total losses in the test object. It is highly responsive, however, in detecting significant differences in structure and physical properties in metallic materials. It can be used successfully to compare internal stresses, and can reject highly stressed pieces which are liable to crack or fail in service. Used at low frequency, it reveals differences in structure, chemical analysis or heat treating histories in the specimen. By the use of suitably high frequencies, the Cyclograph can be used to compare case depths, cladding or plating thicknesses. At high frequencies, the instrument tests the surface layers of metal, and is not affected by the interior of the specimen.

New models of the Cyclograph are readily portable and much more compact than the original laboratory instrument. The test coils can be fabricated in a variety of sizes and shapes to suit individual applications. By standardizing the instrument settings on acceptable test objects of proper material and fabrication, all those which differ significantly can be automatically sorted and rejected. Included in Cyclograph are selective relays capable of operating marking devices, recording devices, or rejecting defective units from the batch.

Radar-Frequency Methods

Recent developments, including wartime radar developments, have contributed new ultra-high-frequency methods of electromagnetic-induction nondestructive testing. Devices of this sort have been patented but have not yet been made commercially available on a wide scale to industry. However, they serve certain special purposes which justify their inclusion in this paper. Since radar and electronic equipment for this type of measurement is being commercially produced on a large scale, units of this type could be developed commercially where necessary to suit industrial applications.

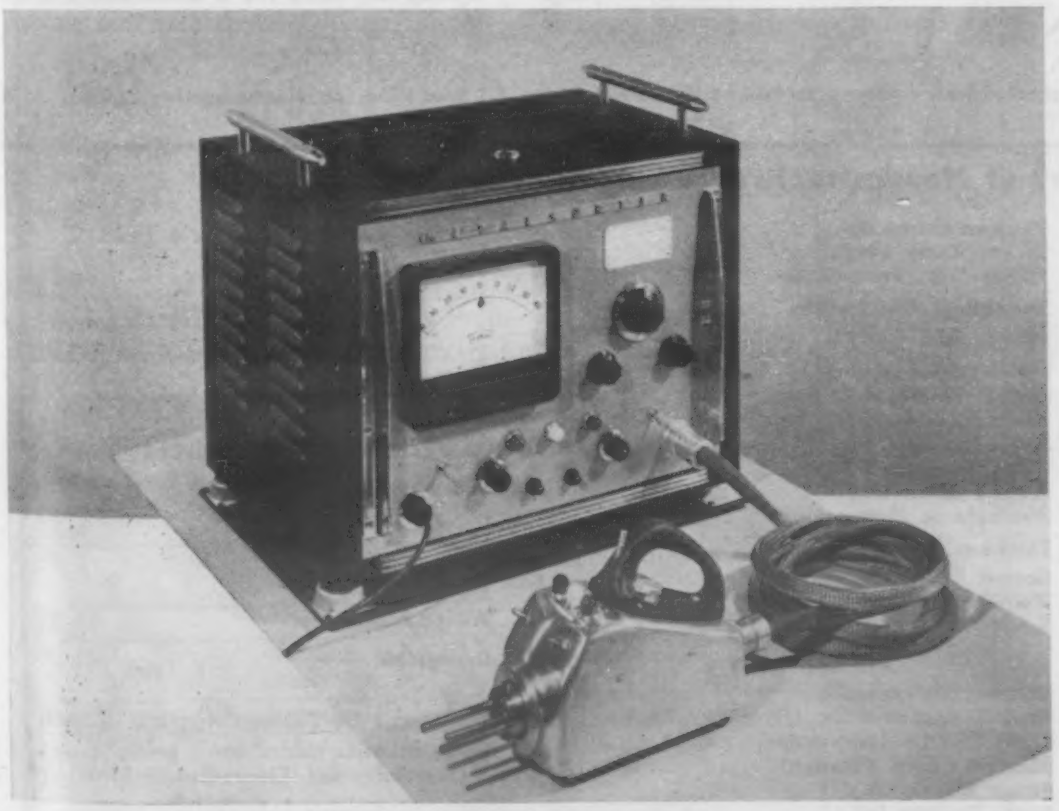
One patented technique uses high-frequency radar waves to measure the electromagnetic properties of thin coatings and surface layers of test objects. In these tests, a wave guide or cavity oscillator is coupled with the test object. The high-frequency radar waves reflected from the test object provide an indication of the surface electrical resistance and the thickness of nonconducting coatings. The method is particularly applicable where the surface layers are extremely thin and differ considerably in properties from the underlying material.

Electromagnetic-Induction Thickness-Testing Devices

Electromagnetic-induction nondestructive tests have also been applied to measuring the thickness of thin sheet materials and thin coatings. This can be done in two ways. In the first method, the exciting coil is placed on one side of a thin sheet and the pickup coil on the opposite side. The shielding provided by the test object influences the magnitude of the pickup signal. With material of reasonably uniform properties, this permits direct thickness gaging. With material which has been gaged by other methods, this provides a technique for detecting differences in material structure.

In the second method, a single coil is employed (as in the Ross Gunn tester used to measure the thickness of aircraft propeller blades, or in the Cyclograph). The losses in the exciting coil, or the signal in a separate pickup coil inserted within the same probe, are detected and used as a measure of the thickness and resistivity of the test sheet material. The method has also been applied to measure the thickness of copper and nickel plate, and of composite copper and nickel coatings on steel. Modified forms have been employed for measuring the inside diameter of tubes, the air gap between the pickup probe and surface of the material being detected by electromagnetic induction. German applications have included measurement of the wall thicknesses of a light-metal casting.

Technologists of the Jones & Laughlin Steel Co. developed a simplified form of an electromagnetic-induction comparator to sort steel bars and tubes rapidly and nondestructively. The SteelSorter can be used to separate round bars, hexagonal or flat bars, and tubes of many sizes. It is especially handy when used for inventory control. An analagous principle is employed in the Electro-Carbon Meter. The steel sample is cast in a mold ½ in. in dia, after being "killed" with aluminum wire. For carbon content above 40 points, the specimen is quenched at once. For carbon content below 40 points, the cast sample is cooled in the mold for 1 min, then quenched. The sample is then inserted within the detection coil and the carbon content is indicated by a suitable galvanometer instrument.



This instrument utilizes triboelectric energy and sorts and classifies dissimilar metals. (Courtesy Doschek and Walker, Inc.)

Triboelectric Tests

While triboelectric energy has only recently been adapted to the field of nondestructive testing, it is the oldest form of electrical energy known to man. The triboelectric phenomenon involves the generation of friction between two unlike materials in intimate contact, and the production of an electrostatic charge on the contacting surfaces. There has been considerable work done recently in extending the triboelectric series, over 300 materials having been classified at the present time.

At present, there are two commercially available types of nondestructive testing equipment which utilize triboelectric energy.

MetalSorter

One of these, called the MetalSorter, employs a circuit which will detect the minute quantities of current generated when two metallurgically or chemically unlike conductors are moved in frictional

contact. If both conductors are metallurgically identical, no current will be generated. Occasionally, two unlike conductors will not generate a current of measurable magnitude. However, such conductors can almost always be distinguished from one another by comparing each to a third conductor and using the differential current value as a basis for separation. It should be noted that triboelectric polarity is a function of the metallurgical nature of the conductors and their connection with respect to the measuring circuit; however, the magnitude of the effect is not necessarily a function of the degree of unlikeness. Therefore, the triboelectric magnitudes and polarities of various conductors are obtained empirically. Since these values are all relative with respect to one another, the MetalSorter has been provided with controls for calibrating the instrument to fixed standard values.

The MetalSorter is designed for the sorting or identification of metal parts where not more than four chemically or metallurgically different alloy types are involved. Where more than four types are involved, it may be necessary to make two or three sorts with as many different selective test rods in order to accomplish complete separation. The test can be made on any metal part wherever a small area of clean, scale-free metal surface is available. It can be applied to slabs and billets as well as semifinished and finished parts.

Sorting can be done on either a basis of composition or structural differences. It is often possible to determine, in a relative sense, the differences in degree of cold work in sheet and wire products. A production testing fixture allows the sorting of small parts at a rate of 15 to 20 per min.

Essentially, the equipment consists of a control unit and a portable sorting head which is connected to the control unit by means of a cable. The sorting head contains all the main controls for actuating the test, and is designed for one-handed operation. A standard rod in the form of a bar of known alloy, ¼ by 3 in. long, is fastened into the sorting-head chuck. When the standard rod is placed on the piece to be tested, it completes an electrical circuit. Actuation of the test switch on the head energizes a solenoid which causes the standard rod to be reciprocated against the test piece, and a large electrical meter indicates the character of triboelectric effect produced. Both the sorting head and the control unit contain signal lamps which also indicate the character of the test and eliminates the necessity of the operator having to view the meter after each test.

Present applications of the MetalSorter include sorting, inspection and quality control in a wide variety of metal-producing and fabricating industries.

Statiflux

Another recent development in triboelectric nondestructive testing is Statiflux, which can be broadly referred to as electrified particle inspection. The method will locate cracks or pores open to the surface in nonconducting materials. The method can be used on such diverse items as bottles, glass-lined vessels, porcelain enamel coatings, plate glass, electrical insulators, dentures, plastics, and other nonconductors of low general porosity.

Essentially, the method is rather simple, the test piece being covered with a special penetrant which conditions the defects in preparation for producing indications. However, the penetrant is not required for the inspection of through-to-metal cracks and holes in metal-backed nonconductors, since the metal backing serves as an electron source. After application of the penetrant, the surface is then dried, either in warm air, by air blast, or by wiping. Then a cloud of charged powder particles is blown over the surface, and a line or build-up of powder will appear at the defect.

The powder particles, of suitable color for contrast, are blown from a gun designed to induce electrostatic charges on the particles as they are emitted from the nozzle. As the charged particles are floated in a cloud over the surface to be inspected, they are triboelectrically attracted to the discontinuities in the nonconducting material. The indications build up immediately, are held at the defect by the charge, and clearly mark the defect for ready and rapid visual inspection.

The inspection can be carried out by hand on large or small objects, or can be done automatically on conveyers. With conveyerized semiautomatic operation, one inspector can easily locate defective parts as they pass at very high rates.

Statiflux is capable of detecting extremely fine cracks—so fine that it is sometimes difficult to demonstrate by measurement or other methods that a crack really exists. For instance, the method has detected cracks in clear glass which could not be revealed by light-reflection techniques, which would indicate that the crack is a quarter wave length or less of the light used. This would fix the width of the crack as being in the order of one-tenth of a micron. Using replica methods, it has been possible to locate cracks in porcelain enamel which are approximately one micron in width. Other cracks on the test specimen were revealed by Statiflux and were apparently smaller, since replica methods would not locate them.

As in all new methods, much remains to be learned of the value of this new inspection tool to industry. However, its simplicity, ease of application and interpretation, dependability and sensitivity, and low operating cost would appear to fill a long-felt need for a nondestructive test for the type of defects described above.

Some of the material contained in this Manual was adapted from a paper presented by the authors at the E-7 Symposium on Nondestructive Testing, ASTM Annual Meeting, June, 1950.

Directory of Nondestructive Testing Equipment

Penetrating Radiation Tests

X-ray Generating Equipment

General Electric X-ray Corp.
Kelley-Koett Mfg. Co., Inc.
Machlett Laboratories, Inc. (tubes)
North American Philips Co., Inc.
Picker X-ray Corp.
Standard X-ray Corp.
Westinghouse Electric Corp.

Multi-Million Volt X-Ray Machines

Allis-Chalmers Mfg. Co.
General Electric X-ray Corp.
High Voltage Engineering Corp.

Gamma-Ray Sources (radioactive materials)

Atomic Energy Commission
Canadian Radium & Uranium Corp.
Eldorado Mining and Refining (1944) Ltd.
Radium Chemical Co., Inc.
Tracerlab, Inc.

Films, Screens and Processing Supplies

Ansco
E. I. du Pont de Nemours & Co., Inc.
Eastman Kodak Co.
General Electric X-ray Corp.
Pako Corp.
Patterson Screen Div.
Picker X-ray Corp.
Powers X-ray Products, Inc.

Xeroradiographic Supplies

Haloid Co.

Fluoroscopic Equipment

General Electric X-ray Corp.
North American Philips Co., Inc.
Patterson Screen Div.
Picker X-ray Corp.
X-ray Products Corp.
Westinghouse Electric Corp.

Thickness Gaging Equipment

General Electric Co.
Westinghouse Electric Corp.
Tracerlab, Inc.

Ultrasonic Tests

Branson Instrument Co.
Brush Development Co. (Hypersonic Analyzer)
J. W. Dice Co. (Metroscope)
Magnaflux Corp. (Sonizon)
Saturn Electric Co.
Sperry Products Inc.
(Reflectoscope and Reflectogage)
Tuboscope Div., Tubular Service & Engineering Co.
(Sonoscope)

Magnetic Particle Tests

Magnaflux Corp.

Penetrant Tests

Dy-Chek Co., Div. of Northrop Aircraft, Inc.
(Dy-Chek)
Magnaflux Corp. (Zyglo and Partek)

Electromagnetic-Induction Tests

Magnetic Analysis Equipment

General Electric Co.
Magnetest Corp.
Magnetic Analysis Corp.
Sperry Products, Inc.
Waugh Laboratories

Cyclograph

J. W. Dice Co.
Non-Destructive Testing Corp., Ltd. (Canada)
Fisher Scientific Co.
(SteelSorter and Electro-Carbon Meter)

Triboelectric Tests

Doschek and Walker, Inc. (MetalSorter)
Magnaflux Corp. (Statiflux)

Materials Engineering File Facts

Solder and Brazing Materials

(Continued from January 1951, File Fact No. 204)

Name of Material and Supplier*	% Composition	Flux	Melt. P. Deg F	Flow P. Deg F	Comments
Low Temperature Brazes					
Gold-Indium I.C.A.	Au 80.0, In. 20.0	H_2	1022	1170	Hard, brittle.
RT-SN H.&H.	Ag 60.0, Cu 30.0, Sn 10.0	—	1095	1325	—
Low Melting Hard Solder	Ag 42.0, Cu 33.0, Sn 25.0	H_2	1110	1162	F. C. Hull, West. Res. Lab. Hard, brittle.
	Ag 46.5, Cu 32.5, Sn 21.0	H_2	1110	1180	F. C. Hull, West. Res. Lab. Hard, brittle.
Easy-Flo 45 H.&H. Silvaloy 45 A.P.W.	Ag 45.0, Cu 15.0, Zn 16.0, Cd 24.0	C A.P.1, A.P.2	1125	1145	—
Easy-Flo 35 H.&H. Silvaloy 35 A.P.W.	Ag 35.0, Cu 26.0, Zn 21.0, Cd 18.0	C A.P.1, A.P.2	1125	1295	—
Type 154 G.P.	Ag 45.0, Cu 17.0, Zn 16.5, Cd 20.5, Sn 0.5, Pb 0.5	—	1135	1150	Extremely wetting on nonferrous and ferrous metals.
Silvaloy 40 A.P.W.	Ag 40.0, Cu 18.0, Zn 15.0, Cd 27.0	A.P.1, A.P.2	1135	1205	—
ATT H.&H.	Ag 20.0, Cu 45.0, Zn 30.0, Cd 5.0	C	1140	1500	ASTM Spec. B-73-29. No. 3. Brass yellow.
Silvaloy 355 A.P.W.	Ag 56.0, Cu 22.0, Zn 17.0, Sn 5.0	A.P.2	1152	1203	White; for stainless steel and other white metals.
Easy Flo H.&H. Silvaloy 50 A.P.W. KH-7 G.P.	Ag 50.0, Cu 15.5, Zn 16.5, Cd 18.0	C A.P.1, A.P.2	1160	1175	For ferrous and nonferrous use. Yellow, mech. strong.
Nu-Braze Grade VI SH	Ag, Cu, Zn, Cd	NB	—	1175	—
	Ag 50.0, Cu 15.0, Zn 25.0, Cd 10.0	—	1166	1190	—
Sil-Fos H.&H. Silvaloy 15 A.P.W.	Ag 15.0, Cu 80.0, P 5.0	A.P.1, A.P.2	1185 1185	1300 1280	For copper and its alloys. Gray-white.
Easy-Flo #3 H.&.H. Silvaloy 503 A.P.W. KH-4 G.P.	Ag 50.0, Cu 15.5, Zn 15.5, Cd 16.0, Ni 3.0	C A.P.1, A.P.2	1195	1270	For ferrous and nonferrous metals when fillets are required. Yellow, strong.
SN #7 H.&H.	Ag 7.0, Cu 85.0, Sn 8.0	—	1225	1805	—
Low Melting Hard Solder	Ag 53.0, Cu 32.0, Sn 15.0	H_2	1238	1290	F. C. Hull, West. Res. Labs. Very hard, brittle.
SS H.&H. Silvaloy 250 A.P.W.	Ag 40.0, Cu 30.0, Zn 28.0, Ni 2.0	C A.P.1, A.P.2	1240 1222	1435 1416	Pale yellow. For carbide tool tipping at higher temperatures.
ET H.&H. Silvaloy A-28 A.P.W.	Ag 50.0, Cu 28.0, Zn 22.0	C A.P.1, A.P.2	1250	1340	Yellow white.
DE H.&H. Silvaloy A-18 A.P.W.	Ag 45.0, Cu 30.0, Zn 25.0	C A.P.1, A.P.2	1250	1370	Yellow white. ASTM B-73-29. No. 4. Fed. Gov. Agencies Spec. QQ-S-561d, No. 1.
R.T. H.&H. Silvaloy A-33 A.P.W.	Ag 60.0, Cu 25.0, Zn 15.0	C A.P.1, A.P.2	1260	1325	Silver white (for tungsten to copper with NaCN flux).
SH-7 G.P.	Ag 60.0, Cu 20.0, Zn 7.0, Cd 10.0, Sn 3.0	A.P.1, A.P.2	1270	1300	All ferrous and nonferrous metals and alloys.
E.T.X. H.&H. Silvaloy A-25 A.P.W.	Ag 50.0, Cu 34.0, Zn 16.0	C A.P.1, A.P.2	1275 1272	1425 1425	ASTM B-73-29. No 5.
Easy H.&H. A.P.W. SK-4 G.P.	Ag 65.0, Cu 20.0, Zn 15.0	C —	1280 1285	1325 1325	ASTM B-73-29. No. 6. Silver white for sterling silver.
SB-2 G.P.	Ag 60.50, Cu 22.5, Zn 7.0, Cd 10.0	—	1285	1335	Flux or atmosphere for nonferrous only.
TR #1 H.&H.	Ag 75.0, Zn 25.0	C	1300	1345	—
KK-5 G.P.	Ag 55.0, Cu 31.5, Zn 11.7, Ni 1.8	H_2	1300	1355	Fluxless brazing, particularly of ferrous metal.
Phos Copper—Westinghouse	Cu 93.0, P 7.0	None	1304	1382	For nonferrous metals.
Low Melting Hard Solder	Ag 59.0, Cu 31.0, Sn 10.0	H_2	1328	1360	F. C. Hull. Very hard; can be swaged, low vapor pressure.

(Continued on page 99)

"I've discovered the newest way to cut refractory costs!"

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B&W ALLMUL

...the economical fused-mullite firebrick

WHAT IS ALLMUL? B&W ALLMUL Firebrick is composed of practically all tough, massive, interlocking mullite crystals produced in the electric furnace. It has an unusual combination of excellent refractory properties: *high hot load strength, high resistance to spalling, good volume stability and a high melting point of 3335 F.*

B&W ALLMUL costs *far less* than any similar refractory. ALLMUL is designed to slash refractory costs by eliminating the frequent need for furnace relining. In fact, ALLMUL Firebrick will give you a new standard of economy and performance in furnace construction and operation. Already, B&W ALLMUL is being used in such diverse applications as hot metal mixers, glass tanks, electric melting furnaces, burner tile, butt weld furnaces, and many others.

If you are now using fused-mullite refractories, you will be surprised by the low cost of ALLMUL . . . at the savings you can make with this top quality refractory.

If you have always thought fused-mullite refractories cost more than you can pay, economical B&W ALLMUL is well worth investigating.

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WORKS: AUGUSTA, GA.

Materials Engineering File Facts

Name of Material and Supplier*		% Composition	Flux	Melt. P. Deg F	Flow P. Deg F	Comments
DT Silvaloy A-14 CH-1	H.&H. A.P.W. G.P.	Ag 40.0, Cu 36.0, Zn 24.0	C A.P.1, A.P.2 —	1330 1340	1445 1405	Pale yellow. —
Medium	H.&H. A.P.W.	Ag 70.0, Cu 20.0, Zn 10.0	C	1335	1390	For sterling silver; silver white.
MA-1	G.P.	Ag 72.15, Cu 22.8, Zn 5.05	—	1345	1400	—
Hard #1	H.&H.	Ag 75.0, Cu 20.0, Zn 5.0	C	1350	1425	—
LM-1	G.P.	Ag 27.0, Cu 40.15, Zn 32.85	—	1350	1430	—
SM-1	G.P.	Ag 66.7, Cu 28.25, Zn 5.05	—	1360	1395	—
I.T. Silvaloy A-49	H.&H. A.P.W.	Ag 80.0, Cu 16.0, Zn 4.0	C A.P.1, A.P.2	1360	1490	ASTM Spec. B-73-29. No. 8. White.
Hard	H.&H. A.P.W.	Ag 75.0, Cu 22.0, Zn 3.0	C	1365	1450	—
SI-1	G.P.	Ag 68.0, Cu 26.6, Sn 5.0	—	1370	1400	Suitable for vacuum.
N.T. Silvaloy A-13	H.&H. A.P.W.	Ag 30.0, Cu 38.0, Zn 32	C A.P.1, A.P.2	1370	1410	Pale yellow.
RE-Mn	H.&H.	Ag 65.0, Cu 28.0, Mn 5.0, Ni 2.0	C	1385	1445	—
KC-4	G.P.	Ag 54.0, Cu 40.0, Zn 5.0, Ni 1.0	A.P.1, A.P.2, H_2	1430	1470	Ferrous or nonferrous. —
AT Special Silvaloy A-11	H.&H. A.P.W.	Ag 20.0, Cu 45.0, Zn 35.0	C, L2, A.P.2	1430	1500	ASTM Spec. B-73-29. No. 2.
Silvaloy 20	A.P.W.	Ag 20.0, Cu 45.0, Zn 30.0, Cd 5.0	A.P.2	1430	1500	ASTM Spec. B-73-29. No. 3.
B.T. Silvaloy 301 ML	H.&H. A.P.W. G.P.	Ag 72.0, Cu 28.0	C, H_2, L2 A.P.1, A.P.2	1435	1435	Excellent for copper. White. Suitable for vacuum braze.
LH-3	G.P.	Ag 19.45, Cu 47.75, Zn 32.8	—	1440	1500	—
T.L.	H.&H.	Ag 9.0, Cu 53.0, Zn 38.0	C, L2	1450	1565	Brass yellow.
BH-1	G.P.	Ag 10.0, Cu 50.0, Zn 40.0	—	1495	1590	—
N.E.	H.&H.	Ag 25.0, Cu 52.5, Zn 22.5	C, L2	1500	1575	—
Tobin Brazing Bronze		Cu 60.0, Zn 39.25, Sn 0.75	M	1500	1740	Good wear resist., high tensile strength for cast iron or steels.
Silvaloy A-4	A.P.W.	Ag 10.0, Cu 52.0, Zn 38.0	A.P.2	1510	1600	—
Spelter Bronze		Cu 49.0-52.0, Sn 3.0-4.0, Pb 0.5, Fe 0.1, Zn bal.	—	1520	1550	—
T. E. Special	H.&H.	Ag 5.0, Cu 58.0, Zn 37.0	C, L2	1575	1600	—
Spelter or Brazing Solder		Cu 49.0-52.0, Pb 0.5, Fe 0.1, Al 0.1, Zn bal.	—	1600	1620	Common brazing solder for metal work shops.
Gold-Copper Eutectic		Au 80.0, Cu 20.0	D, H_2	1634	1634	Beware brittle joints.
Brazing Solder		Cu 68.0-72.0, Pb 0.3, Fe 0.1, Zn bal.	—	1650	1760	—
Brazing Solder		Cu 78.0-82.0, Pb 0.2, Fe 0.1, Zn bal.	—	1725	1825	—
Gold-Nickel Eutectic		Au 82.5, Ni 17.5	D, H_2	1742	1742	—
		Au 94.0, Cu 6.0	D, H_2	1742	1796	—
Pure Silver		Ag 100.0	D, H_2	1760	1760	—
Silvaloy 850	A.P.W.	Ag 85.0, Mn 15.0	A.P.2, H_2	1760	1778	For stainless steel. When high brazing temperature required.
Pure Gold		Au 100.0	D, H_2	1945	1945	—
Pure Copper (OFHC)		Cu 100.0	H_2	1980	1980	—
Platinum Solder		Ag 73.0, Pt 27.0	H_2	2120	—	Wets tungsten.
Nickel Coinage (Pre-War)		Cu 75.0, Ni 25.0	H_2	2201	—	Wets tungsten.
Nickel		Ni+Co 99.0-99.5, Traces C, Mn, S	H_2	2642	—	Wets tungsten and molybdenum.
Rhodium		Rh 100.0	H_2	3574	3574	For joining W and Mo.

** See File Fact No. 204 (Jan. 1951) for list of suppliers and fluxes*

Here's help in ordering HEAT TREAT POTS!

You can save time and pattern costs by ordering Thermalloy Heat Treat Pots in shapes and sizes available for production. This new bulletin lists 118 pattern numbers available—including both round and rectangular pots.

All Electro-Alloys heat treat pots are x-rayed and pressure tested, to insure the soundness necessary for low cost service. Analyses available for cyanide salt and lead service—and for neutral salt service.

Write for Bulletin T-205. Electro-Alloys Division, Dept. 2082, Elyria, Ohio.

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AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION
ELYRIA, OHIO

New Materials and Equipment

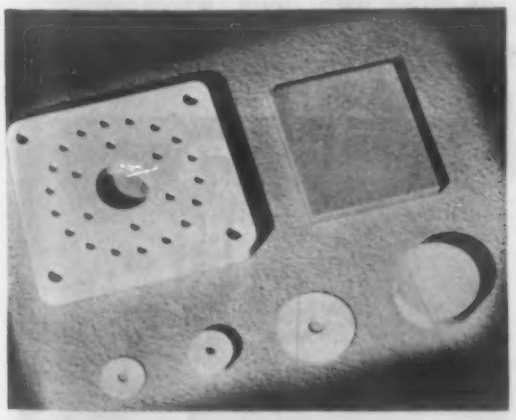
Materials

Technical Ceramics

Unfired blocks of Grade A lava for scientific or product development uses can be secured from *American Lava Corp.*, Chattanooga 5, Tenn. Working models of certain technical ceramic parts can be made and tested in the user's own plant or laboratory.

Said to machine as easily as wood or brass, the material can be used without firing. In this state, its electrical properties are claimed not to differ greatly from its properties after the material is fired. However, in its unfired state, the material has little mechanical strength.

Firing converts the lava to a very hard substance. According to the manufacturer,



The three larger pieces shown here are flat within one to two light bands (0.0000116 to 0.0000232 in.).

shrinkage in firing is nominal, thus permitting unusual dimensional accuracy in the finished part.

Optically flat disks and plates of AlSi-Mag technical ceramics, which are custom made in any size up to 9-in. dia, have also been announced by American Lava Corp.

Hard and rigid, they are also said to be resistant to heat shock and can be used at elevated temperatures. The material is resistant to all alkalies and acids except hydrofluoric acid. According to the manufacturer, dimensional accuracy can be maintained within almost any limits specified.

Plastic Insulating Material

A new laminated plastic designed especially for 60-cycle work has been announced by *The Formica Co.*, 4614 Spring Grove Ave., Cincinnati 32. Designated Z-80, the new material is said to combine three useful properties in one grade:

1. High arc resistance
2. Good dimensional stability
3. Lower power loss at 60 cycles

In addition, the new insulating plastic is claimed to have good punching and excellent machining qualities.

Applications for the new material are predicted in the radio and television industries for use in condensors and adaptors where extremely low loss at 60 cycles is required. It is also expected to fill a similar need in the power generating industry.

Made of a coarse weave fabric and bonded with arc resistant resin, Z-80 is available in sheet form from 1/32 to 1 in. thick, in natural color and semi-gloss finish. It can be laminated and molded to a wide variety of shapes. Z-65, a similar material but with a paper base, is being introduced concurrently with the Z-80.

High Density Metal

Heavier than cemented carbide, and said to possess a 50% greater density than lead, the new non-cutting metal manufactured by *Carboloy Co., Inc.*, Detroit 32, is able to resist the penetration of radioactive rays.

Important uses of this special metal are for balance weights on crankshafts, gyroscopes, variable-pitch propellers, centrifugal clutches, and other similar moving parts. For static and dynamic balancing of such parts, as well as for balancing of aircraft control surfaces, it is claimed to have the advantage of maximum weight with minimum size.

As a high density material, Hevimet is of important use for gamma ray screens as used in radiotherapy and other similar applications.

CONTENTS

Coatings & Finishes

Zinc-Plate Finish

Allied Research Products, Inc., 4004 E. Monument St., Baltimore, Md., has announced a new, low-cost Iridite treatment

New Materials and Equipment
(CONTINUED)

for bright-type finishing of zinc plate in automatic plating machinery.

According to the manufacturer, the new compound's most important advantage is the fact that a protective film can be produced on zinc-plated coatings of less than 0.0001-in. thickness. Thus, the use of the new material is expected to enable manufacturers of zinc-plated products to stretch available zinc supplies. Other advantages claimed for the new compound are that it is completely flexible in use and can be applied with an immersion time from 20 sec up to more than 1 min; it requires no bleaching; and no close controls or special equipment is needed for installation.

In appearance the coating is bluish bright or yellow iridescent. Corrosion resistance varies upwards with the intensity of the iridescence.

Cost of application per square foot ranges from as low as 3/100¢ for strip mill plating operations to only 1/10¢ on piece parts in automatic plating machines.

Hard Chromium Plating Process

Recently developed by the Industrial Chrome Div., *Ward Leonard Electric Co.*, Mount Vernon, N. Y., the new economical industrial hard chromium plating process embodied in the Model A-20 Chromaster and Chromasol is said to increase the normal life of most cutting tools three to ten times.

The Chromaster provides complete facilities for hard chromium plating metal surfaces up to 10 sq in. at the recommended current density of 2 amp per sq in.

Powered by a dry disk, power pack, selenium rectifier, the Chromaster is complete with plating bath tank, heavy duty rheostat, timer, ammeter and reversing switch for stripping action. It is a completely portable compact unit. According to the manufacturer, the hard chromium deposition can be controlled to tolerances of less than 0.0001 in. with this unit.

Operating at room temperature, Chromasol is a new, non-critical chromium plating solution which is shipped to the user in a liquid concentrated form. The solution is said to produce a hard chromium plate that follows the exact characteristics of the base metal to which it is applied. Rate of deposition remains constant at 0.002 in. per hr.

Friction is claimed to be reduced 12 to 20% through the use of this process, which requires 1½ min. for operation.

Protective Coating

Designed as a maintenance coating for steel, wood and cement, the new Neoprene coating manufactured by *Gates Engineering Co.*, P. O. Box 1711, Wilmington, Del., is said to possess all the temperature, abrasion, fume, acid and oil resistance properties of Neoprene.

Easily applied without any special equipment, this new system of maintenance does not require any primers, accelerators, tie coats or heat curing. According to the manufacturer, the coating should last for years if these simple instructions are followed:

1. Loose dirt, grease or oil should be eliminated.
2. Scale and rust must be removed with a wire brush.
3. Then, one coat (10 to 12 mils if brushed on—15 to 20 mils if sprayed) is applied. For extreme duty, more than one coat can be applied with about 1-hr drying time between coats, and will be tack free within an hour.

Film strength and bond of Gaco Neoprene Maintenance Coating is said to increase over a period of time, and depending on the base surface, it usually reaches its maximum after one week.

New Finish for Aluminum

A new low cost material for finishing aluminum which can be used either as a base for paint or to protect the bare metal from corrosion has been announced by *Chemclean Products Corp.*, 64 Sixth Ave., New York 13.

Called Protecto-Cote, the material is available already mixed and needs only to be dissolved in water, 6 oz per gal.

Treatment consists of immersing the metal in the solution at 185 F for about 5 min. No electric current is required, and equipment used in the process consists only of steel tanks with heating facilities. The solution is said to be self-cleaning, making the process a one-operation job. Cost of operation, therefore, is claimed to be very low.

Protecto-Cote can be used on machine parts as well as for decorative consumer products. As a base for paint, it provides a high degree of adhesion, and its corrosion resistance is said to be extremely high.

Steam Spraying Equipment

A complete line of equipment for spraying paint with steam, which includes a new spray gun that uses super-heated steam instead of compressed air, has been

New insulation and radiation design features of this S-100 steam spray gun dissipate the heat caused by the steam in the gun.

New Materials and Equipment

announced by the Kellogg Div., *American Brake Shoe Co.*, 97 Humboldt St., Rochester 9, N. Y.

Recently developed and patented by E. I. duPont de Nemours, steam spraying uses dry, super-heated steam as an atomizing medium which serves to heat the finishing material and makes it possible to use materials of higher viscosity.

Advantages of the new process are said to include:

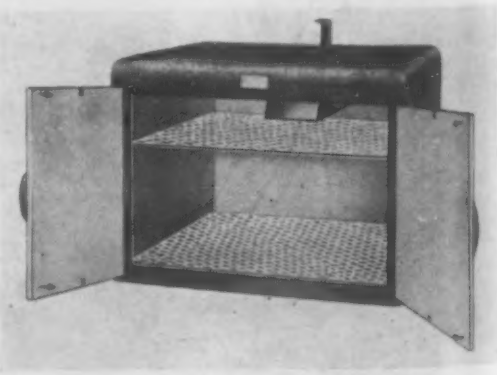
1. Savings of 10 to 20% through the reduction of over-spray atomization losses, in addition to savings in solvents and thinners realized through the use of finishing materials higher in solids.
2. Increased thickness per coat.
3. Continuous high volume finishing operations.

Equipment required for the process can be installed at moderate cost. A source of steam at not less than 100 psi is required.

Heating, Heat Treatment

Portable Electric Oven

Manufactured by *Grieve-Hendry Co., Inc.,* 1101 N. Paulina St., Chicago 22, a new portable industrial electric oven is said to be practicable for baking enamels, lacquer, wrinkles and other finishes;

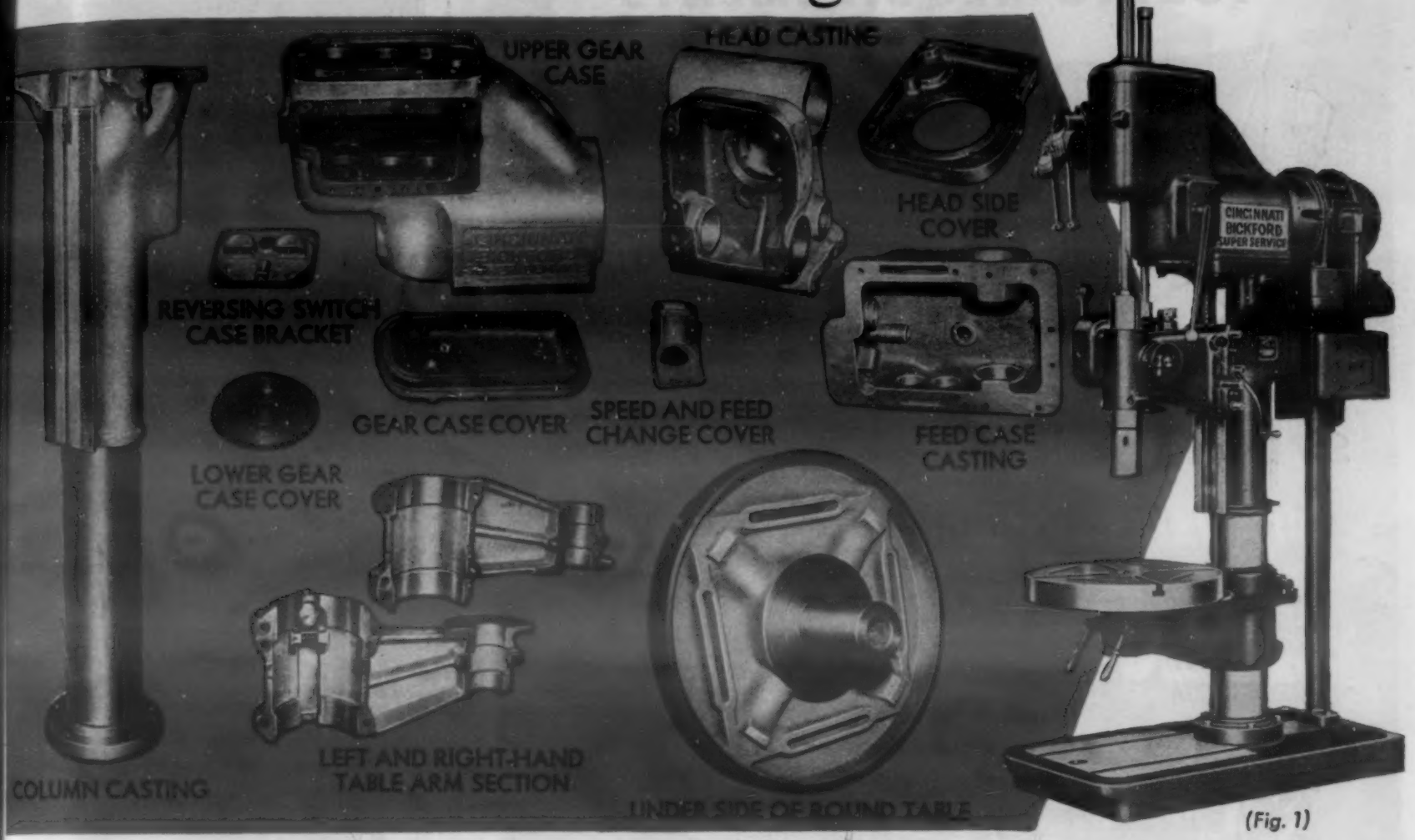


This portable electric oven, Model CR-1, has a single phase 110-v motor and can be operated from any 110-v outlet—no special wiring is required.

for dehydrating bobbins, coil forms, paper tubing; for drying plastic granules, parts after cleaning; and for preheating molds.

Outstanding features of this new low-cost oven include uniform temperature,

ANOTHER Machine Tool Made Better with MEEHANITE® *Castings*



(Fig. 1)

The modern streamlined production tools like the Super Service Uprights (Fig. 1), manufactured by Cincinnati Bickford Tool Company, Cincinnati, Ohio, are built with many Meehanite castings. All of the truly *vital* castings are Meehanite metal. A few are illustrated.

In the manufacture and sale of a machine tool of this type it is a long road between the drawing board and the customers' production floor. The correct specification of proper materials for component parts to translate maximum design superiority into product superiority, is of major importance. That is why wherever quality products are built; where better engineering properties combined with uniformity and repeated dependability are required,—Meehanite castings are specified and insisted upon.

Take advantage of Meehanite engineering service—send your blueprints for analysis and specific recommendation to the foundries listed below.

Take Your Casting Problems To A MEEHANITE Foundry!

American Brake Shoe Co.	Mahwah, New Jersey
The American Laundry Machinery Co.	Rochester, New York
Atlas Foundry Co.	Detroit, Michigan
Banner Iron Works	St. Louis, Missouri
Barnett Foundry & Machine Co.	Irvington, New Jersey
E. W. Bliss Co.	Hastings, Mich. and Toledo, O.
Builders Iron Foundry, Inc.	Providence, Rhode Island
Continental Gin Co.	Birmingham, Alabama
The Cooper-Bessemer Corp.	Mt. Vernon, Ohio and Grove City, Pa.
Farrel-Birmingham Co., Inc.	Ansonia, Connecticut
Florence Pipe Foundry & Machine Co.	Florence, New Jersey
Fulton Foundry & Machine Co., Inc.	Cleveland, Ohio
General Foundry & Manufacturing Co.	Flint, Michigan
Greenlee Foundry Co.	Chicago, Illinois
The Hamilton Foundry & Machine Co.	Hamilton, Ohio
Johnstone Foundries, Inc.	Grove City, Pennsylvania
Kanawha Manufacturing Co.	Charleston, West Virginia
Koehring Co.	Milwaukee, Wisconsin
Lincoln Foundry Corp.	Los Angeles, California
E. Long Ltd.	Orillia, Ontario
Otis Elevator Co., Ltd.	Hamilton, Ontario
The Henry Perkins Co.	Bridgewater, Massachusetts
Pohlman Foundry Co., Inc.	Buffalo, New York
Rosedale Foundry & Machine Co.	Pittsburgh, Pennsylvania
Ross-Meehan Foundries	Chattanooga, Tennessee
Shenango-Penn Mold Co.	Dover, Ohio
Standard Foundry Co.	Worcester, Massachusetts
The Stearns-Roger Manufacturing Co.	Denver, Colorado
Traylor Engineering & Mfg. Co.	Allentown, Pennsylvania
Valley Iron Works, Inc.	St. Paul, Minnesota
Vulcan Foundry Co.	Oakland, California
Warren Foundry & Pipe Corporation	Phillipsburg, New Jersey

"This advertisement sponsored by foundries listed above."

MEEHANITE® PERSHING SQUARE BUILDING • NEW ROCHELLE, N. Y.

New Materials and Equipment

fresh air being drawn in and stale air driven out through specially located vents by means of a motor-driven fan. An adjustable damper gives a wide range of constant temperature.

Constructed of heavy gage steel with asbestos air-cell insulation, the unit measures 29 by 24 by 20½ in. According to the manufacturer it is capable of heating to 225 F in 15 min.

Melting Furnace

A new L-P melting furnace has been announced by *Weldit, Inc.*, 990 Oakman Blvd., Detroit 6. Constructed of steel and cast iron, the Weldit #500 furnace is said to melt 25 lb of lead in 4½ min.

This new Weldit furnace can be used with any standard liquid petroleum tank and requires no gas regulator.

Other advantages claimed for the new furnace are:

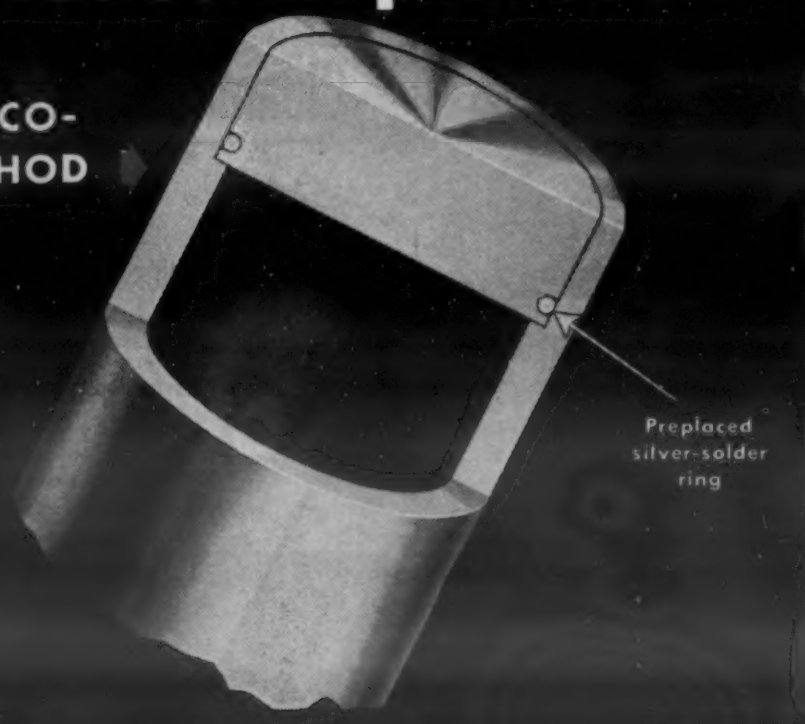
1. Adjustable to maintain temperatures.
2. Burns 15 hr full blast or with intermittent melts; sustaining flame burns up to 60 hr.
3. Designed for use with any standard liquid petroleum tank (no gas regulator required).

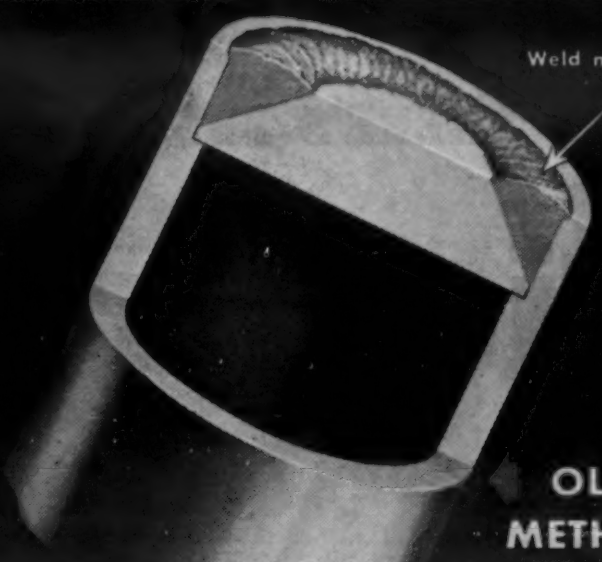
An additional feature of the new furnace is that it can be used with remote fuel service, thereby eliminating fire hazards.

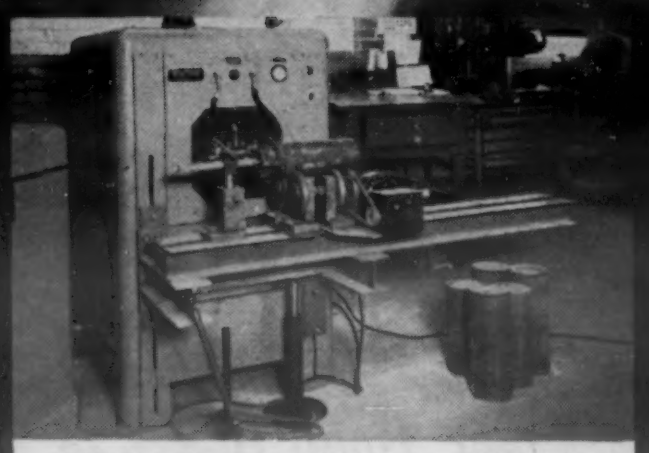
Production Doubled

Cost Cut 50%

Product Improved...







TOCCO heating station with inductor and fixture for silver brazing cylinder and cylinder cap assemblies.

with TOCCO* Induction Heating

The experience of The Commercial Shearing and Stamping Company, who use TOCCO for silver-brazing hydraulic cylinder assemblies, is typical of the benefits obtained by America's leading metal-working plants who use TOCCO Induction Heating for brazing, hardening, heat-treating, forging and melting operations.

More Production with TOCCO

a. Heating time per piece cut from 15.3 minutes to 2 minutes on 5¼" I.D. cylinder.

b. Machining and cleaning operations, formerly required, are not needed after TOCCO brazing.

Lower Costs with TOCCO

a. Through a reduction in time required for each piece.

b. Through the elimination of scrap and reworks.

c. Because, since TOCCO is automatic, operator need not be trained or especially skilled.

Improved Product with TOCCO

a. Because of better looks and sales appeal.

b. Because distortion is minimized.

c. Because of elimination of field failures due to severe stress pockets.

TOCCO Engineers— can probably find applications in your plant, too, where TOCCO Induction Heating can increase output, cut unit costs and improve your product. Such a survey costs you nothing—and may save you a great deal.

THE OHIO CRANKSHAFT COMPANY

Mail Coupon Today

NEW **FREE** BULLETIN

THE OHIO CRANKSHAFT CO.
Dept. T-2, Cleveland 1, Ohio

Please send copy of "A TOCCO Plant Survey—Your Profit Possibility for 1950".

Name_____

Position_____

Company_____

Address_____

City_____ Zone____ State_____

New Materials and Equipment

Cleaning & Finishing

Touch-Up Sprayer

A new tool for touch-up spray painting which applies the original factory finish from a self-pressurized container has been developed by *Sprayon Products, Inc.*, 2075 E. 65th St., Cleveland 3.

Hermetically sealed, the self-spraying tool is said to process any lacquer or

This convenient self-spraying touch-up tool can be used for reconditioning damaged surfaces.

enamel in providing a convenient and inexpensive means of reconditioning damaged surfaces.

The tool can be operated an unlimited number of times, according to the manufacturer, with uniform pressure and fine mist spray pattern regardless of remaining contents.

Steam-Jet Cleaner

Recently developed by *Livingstone Engineering Co.*, 100 Grove St., Worcester 5, Mass., the new low-cost steam-jet cleaner is an all-electric, portable unit which features simplicity of operation.

In contrast to the fuel-fired steam cleaning machines, which depend on hot water and large quantities of solvents under

It pays to use your custom molder's know-how

When "high-cost" products need popular price tags

Lower cost, broader market results from use of plastics for humidifier components.

No. 25 in a Series on Plastics Skill at Work . . .

MOLDED OF DUREZ PHENOLIC, the motor hood and mount are unaffected by water vapor that surrounds them or heat generated by the motor they enclose. They are formed to exact shape in molding press, need no finishing other than simple flashing.

PROJECT: All-purpose automatic humidifier to sell at moderate price.

CUSTOMER: Daffin Manufacturing Company, Lancaster, Pa.

MOLDER: American Insulator Corporation

MATERIAL: All plastics except motor. Center pan, motor mount and hood, Durez phenolics.

CENTER PAN SUPPORTS MOTOR and housing on screw inserts fixed in position as part of the molding operation. By using Durez, the molder fulfilled his customer's specifications at a fraction of the cost that other materials would have entailed.

This humidifier shows how "high-cost" ideas are made financially practical for wider use . . . and wider sale . . . with the aid of men who mold Durez plastics.

The Model 500 is a small counterpart of Daffin industrial humidifiers. To make humidification economical for hatchery and farm use, in egg storage rooms, cold storage rooms, chemical plants, textile mills, hospitals, and in the home, this company developed a small motorized unit which evaporates over 3 pounds of water per hour at a current cost of 3 cents a day.

With engineering details completed, the problem was put up to the custom molder. The molder recommended a Durez phenolic especially developed to withstand the heat and moisture encountered in humidifiers. It has excellent molding qualities and dimensional stability, and is formed into complicated parts at a fraction of the cost of the usual metals. Meeting all electrical and mechanical specifications, Durez made it possible to price the unit for ready sale in markets previously closed on the score of high cost.

Your molder is always a good man to consult when better appearance, faster production, or lower cost are your objectives. He takes full advantage of the able counsel of Durez technicians, who specialize in the most versatile group of plastics, the phenolics. Call on him . . . and them . . . freely.

Our monthly "Durez Plastics News" will keep you informed on industry's uses of Durez. Ask us to send a copy regularly. Durez Plastics & Chemicals, Inc., 1402 Walck Road, North Tonawanda, N. Y.

DUREZ

PHENOLIC RESINS

- MOLDING COMPOUNDS
- INDUSTRIAL RESINS
- PROTECTIVE COATING RESINS

PHENOLIC PLASTICS THAT FIT THE JOB

New Materials and Equipment

pressure for cleaning action, the new JC-20 uses steam from the built-in high pressure Speedylectric boiler. Small quantities of solvents are said to be used effectively and economically as they are not diluted by mixing with gallons of water at the jet.

According to the manufacturer, dirt, grease and oil disappear before the high velocity jet of hot, dry steam and solvents applied instantly as needed under push button control of the operator.

An added advantage claimed for the unit is that it is free of low water danger, as the boiler water itself is the electric resistance heating element. If there is no water, no current passes and no steam is generated.

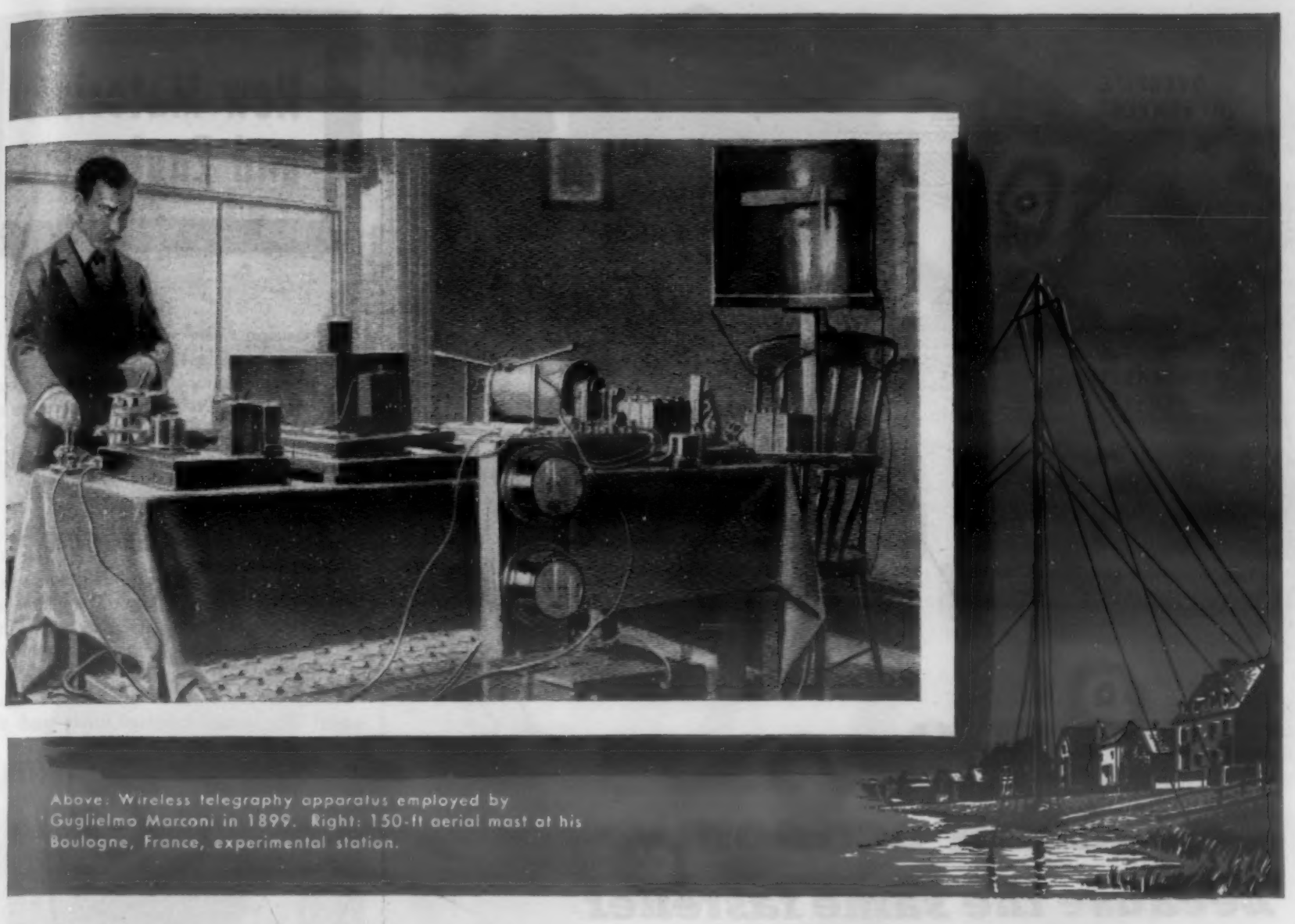
Rated at 20 kw max, the cleaner under ordinary conditions consumes 15 kw per hr. Operating cost is estimated at 30¢ per hr.

Welding & Joining

Welding Machines

A special 300-amp gasoline engine driven arc welder with a 3-kw auxiliary power generator is currently being manufactured by *Hobart Brothers Co.*, Hobart Square, Troy, N. Y. This self-contained unit is powered by a 6-cylinder self-starting Chrysler industrial engine directly connected to the welding generator and mounted on a welded steel frame. An auxiliary 3-kw power generator provides for lights and such tools as grinders, drills, power wrenches, valve refacer, brake reliner, chipping hammers and a lathe.

Another welding unit which was recently announced by *Hautau Engineering Co.*, Detroit, for volume production of automotive transmission brake bands, is a new special, 30-station Cyclewelding machine. Featuring economical compactness of design through the use of space-saving square cylinders, developed by Miller Motor Co., Chicago, the machine is built into an unusually compact 9½-ft dia circular table, allowing accessibility to center slip rings and air headers from a stand-



Above: Wireless telegraphy apparatus employed by Guglielmo Marconi in 1899. Right: 150-ft aerial mast at his Boulogne, France, experimental station.

Rendezvous With MASTERY

1899—and a young man, near Boulogne, France, presses the key of a transmitter. Instantly, his message clicks out on a receiver in Dover, England—32 miles distant. The way has been opened to mastery of instantaneous, world-wide communication.

1899—and a Board of Directors of an infant firm, convening for its initial meeting in Newark, N. J., hears the Treasurer state that $1,400 is at the disposal of Driver-Harris Company with which to commence business. The way has been opened to mastery of new facts and techniques which will provide industry with quality metal products never before available.

"Wireless" has been developed with phenomenal speed since the day Marconi's message was successfully transmitted from Boulogne. Within fifty years—as radio, television, and radar—it has been made to circle and serve the world.

And Driver-Harris, expanding within the same fifty years until represented on all five continents, has produced many of the alloys required. For example: Gridnic* for electron tube grid wire, alloys for radio cathode sleeves and glass seal metals, Karma* and D-H Manganin for resistors, and universally famous Nichrome* and Nichrome V for resistors, plates and other components.

Today, Driver-Harris' specialized knowledge and extensive facilities are employed in supplying superior alloys for a host of applications in numerous fields. The name "Driver-Harris", indeed, has become so widely accepted as a synonym for quality that the demand for D-H products is engaging the resources of the firm to an unprecedented extent. Driver-Harris can only say it is utilizing all the mastery at its command to meet this exceptional demand as fully as possible.

Makers of Nichrome and over 80 other alloys for the electrical, electronic, and heat-treating fields.

SPECIAL PURPOSE ALLOYS SINCE 1890 — D/H — TRADE MARK REG. U. S. PAT. OFF.

Driver-Harris Company

HARRISON, NEW JERSEY

BRANCHES: Chicago, Detroit, Cleveland, Los Angeles, San Francisco

In Canada: The B. GREENING WIRE COMPANY, LTD., Hamilton, Ontario, Canada

*T.M. REG. U. S. PAT. OFF.

New Materials and Equipment

ing position. The work table is said to rotate at variable speeds of from 3 to 6 min per revolution, depending upon cure time required. Cyclewelding operation requires about 450 F temperatures and 200- to 450-psi lining area pressures.

New Hand Welding Equipment

A new hand torch and automatic wire drive unit for argon metal arc welding has been announced by *The Linde Air Products Co.*, 30 E. 42nd St., New York 17.

Consisting of the Linde FSH-4 argon metal arc hand-welding torch and the

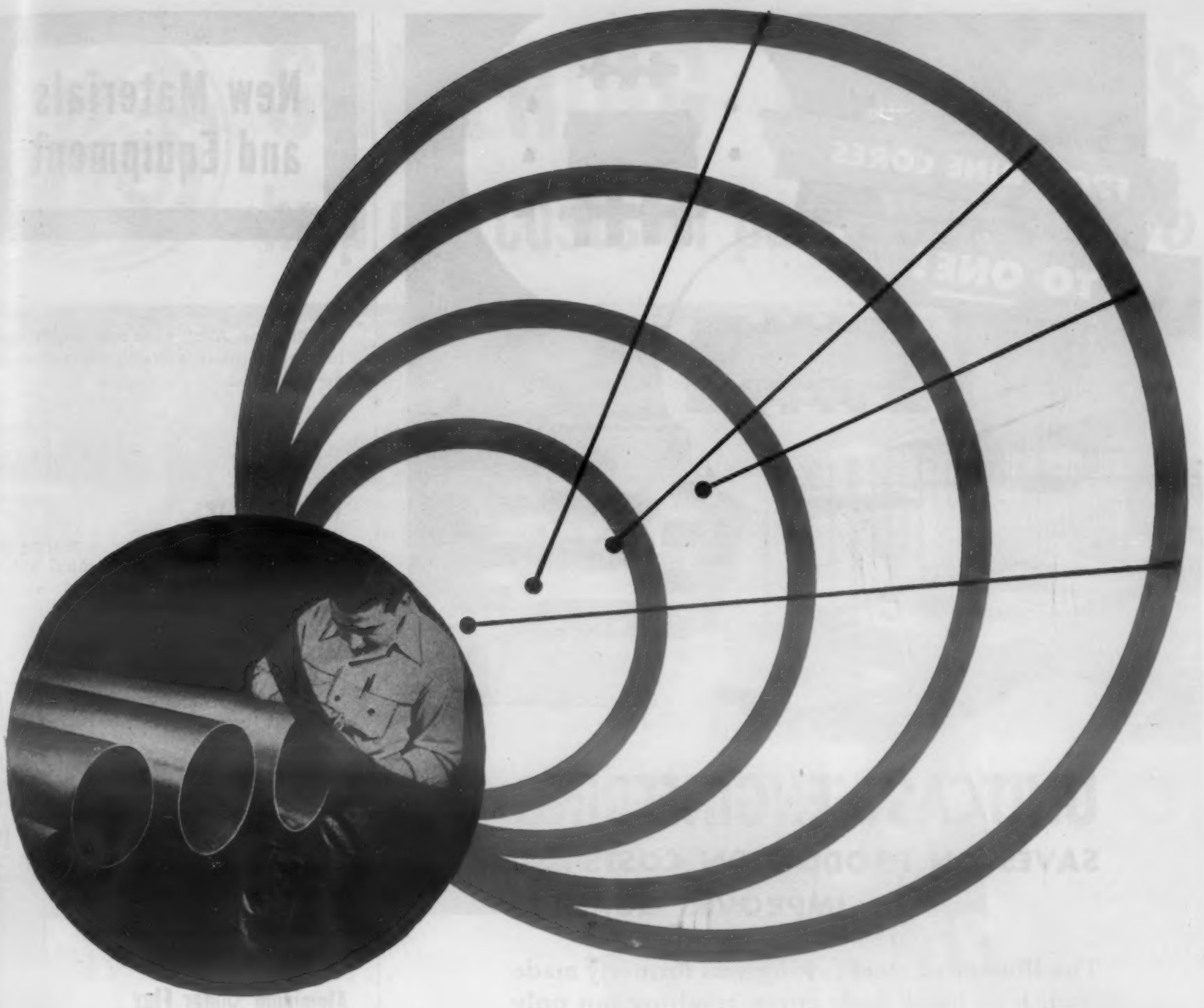
Here an aluminum truck body is being welded with the new hand-welding unit.

FSM-2 rod feed unit, the torch is said to be particularly adaptable for welding aluminum in ranges of thickness from ⅛ to 1½ in.

Principal features of the new welding unit are:

1. Automatic operation: Rod feed, argon flow, and cooling water are automatically controlled.
2. Electric governor: For accurate and uniform control of rate of rod feed. (Rate varies from 80 to 380 in. per min.)
3. Lightweight construction: Unit is readily portable.
4. Simplicity of operation.

Hand welding is said to be applicable



engineers who design for long life specify TRENTWELD

Here are 7 reasons why TRENTWELD is better

1. Largest variety of sizes — 4½" to 30" inclusive
2. Finished tubing... machine-formed, machine-welded, machine-sized for uniformity
3. Made in a *tube* mill by *tube* experts
4. Made from tested cold rolled sheets ... completely fused into finished tubing *without* added rod metal
5. No zone of weakness for corrosion to attack
6. Uniform section, metallurgically correct
7. Available for fabrication with any fittings

Trentweld Large Diameter (4½" to 30") Stainless Steel Tubing should not be compared to rolled up and hand welded sheets: Trentweld tubing is machine formed and machine welded without metal added. The weld is fused to the parent metal by an exclusive Trent development. That's what makes the difference, and that's why more and more fabricators, designers and manufacturers of all types of processing equipment are turning to Trent for their tubing requirements.

When you do business with Trent, you get top quality tubing PLUS engineering assistance to put stainless tubing to work in your application ... better! Write for Trentweld Data Bulletin and tell us the application you have in mind.

TRENT TUBE COMPANY
Subsidiary of Crucible Steel Company of America
General offices and plant: East Troy, Wisconsin
Sales offices in principal cities

TRENTWELD

STAINLESS STEEL TUBING

New Materials and Equipment

on butt, lap, fillet, edge and corner joints in the overhead, vertical, horizontal and flat positions.

Welding Fluxes

Designed to meet the increasing demand for more efficient chemical aids to welding, an expanded line of welding fluxes has been announced by *Eutectic Welding Alloys Corp.*, 40 Worth St., New York 13.

According to the manufacturer, the new Flotectic fluxes reduce surface tension to a greater extent than conventional materials.

Included in the new flux line is Flotectic Flux 1100, which is said to be capable of reducing silver solder costs by cutting down on the amount used per weld, as well as speeding up production by insuring rapid flow with maximum capillary action.

Aluminum Solder Flux

All-State Welding Alloys Co., Inc., 273 Ferris Ave., White Plains, N. Y., is now marketing an improved aluminum solder flux that can be reactivated after drying out by the addition of tap water.

This new flux can be used, according to the manufacturer, with aluminum solder rods of any commercially available brand. Soldering can be accomplished with an open flame and, under certain conditions, with a soldering iron. In addition, the flux permits soldering aluminum to such metals as copper, steel and bronze.

Fastening Pin

Designed to eliminate the tedious time-consuming job of removing cotter pins and nuts from bolts in awkward positions on mechanical equipment and machinery, the new Pip pins manufactured by *Aviation Development, Inc.*, 2940 N. Hollywood Way, Burbank, Calif., can be used for shackle purposes, or as tie-down fastenings.

A quick release pin, used like a bolt, the unit is merely inserted into holes in the parts to be held. Once in place, the pins cannot become loose. They are claimed to be capable of taking very high shear and axial loads regardless of size and type.

SINTERING FURNACES

help cut costs of parts 60 to 90%

AS REPORTED BY...

P. V. Schneider, Chief Metallurgist

Powdered Metal Products Corp. of America

Franklin Park, Illinois

"Because our G-E sintering furnaces give uniform temperature throughout the heating zone we're able to sinter many intricate parts which formerly required machining—with production savings from 60 to 90 per cent!

"For example, our G-E sintering furnaces helped us cut production costs on gear pawls by 60 per cent, and on governor weights by 90 per cent.

"In short, we're well pleased with the performance of our G-E furnaces, which have been in service since 1948."

To help you turn out better products, faster, and at lower cost, General Electric offers a complete line of electric furnaces and associated equipment, including atmosphere producers, induction heaters, small heaters and heating devices. Contact the G-E Sales Office nearest you or write: *Apparatus Department, General Electric Company, Schenectady 5, N. Y.*

ELECTRIC FURNACES

Annealing Brazing Drawing
Carburizing Enameling Hardening
Galvanizing
Normalizing Sintering

You can put your confidence in—

GENERAL ELECTRIC

New Materials and Equipment

At the present time, the new product is finding applications in the aircraft and industrial fields, as well as in the motion picture, armament and railroad industries in a wide variety of shackle, hinge pin and attachment uses.

●

Forming & Machining

Grinders

Recently announced by *The Blanchard Machine Co.*, 64 State St., Cambridge 39, Mass., the new #16A3 vertical spindle rotary table surface grinder can be equipped with a magnetic chuck 40 in. in dia, or a plain table to accommoda a fixture to hold nonmagnetic work or pieces of irregular shape. Three abrasive wheels are part of the grinder's assembly. These can be set to grind the same surface when stock removal is heavy, or very accurate tolerances for dimension or surface finish are required.

Another type of grinder, currently being manufactured by *George F. Grant Co., Inc.*, 43 Kempton Place, West Newton, Mass., is a practical precision belt grinder which is said to offer many uses in tool, pattern and die making machine shops, and production and woodworking shops. When used as an accessory to any drill press, the new Grant contour grinder is said to eliminate the need for extra space. Using standard 2½- by 60-in. belts, this grinder is claimed to offer both efficiency and economy for job or production runs.

A third type of grinder now being offered by *Rivett Lathe & Grinder, Inc.*, Boston, is a new universal hydraulic grinder, the Rivett 1024. Swiveling 180 deg and mounting both internal and external spindles, the unit is designed to eliminate dual work set-ups for internal and external grinding. Said to have been constructed to perform all types of grinding, the unit is applicable for internal work, including small, large and deep hole grinding; and external work, including straight shaft, long shaft, diameter and shoulder grinding.

Another addition to the series of grinders is a new internal grinder manufactured by *South Bend Lathe Works*, South Bend 22, Ind. Developed to meet the need for an internal grinding attachment having sufficient power to maintain a more con-

HOW TO IRON OUT PHENOLIC MOLDING PROBLEMS

The answer is Borden's DURITE.

The handle above illustrates how Borden engineers custom-design the DURITE compound for the job. Through experimentation, heat resistance and low heat conductivity . . . two hard-to-blend features . . . were combined.

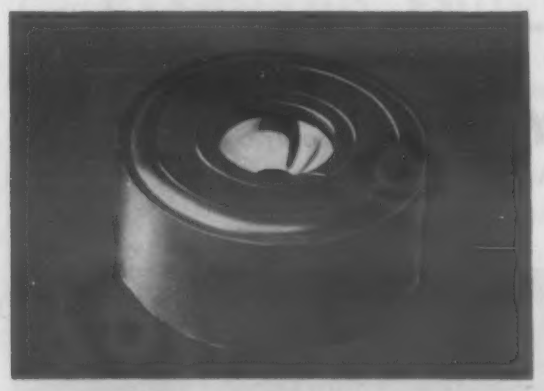
For utensil handles, ignition systems, components of electrical equipment, specify Borden's DURITE HR-300. It molds a product that stays strong and lustrous despite heat, has high impact and flexural strength. Its economical 1.39 specific gravity gives you more heat-resistant parts per lb., easier handling and moldability.

In DURITE, Borden gives you the special properties you need, in the degree you want, by skillful combining of cellulosic, carbonaceous and mineral fillers with the resin base. Address your molding problems requiring Phenolic Molding Compounds to The Borden Company, Chemical Division, Dept. MM-21, 350 Madison Ave., New York 17, N. Y.

Borden's DURITE

Molding Powders • Bonding Resins • Cements

Water-and-soap resistance, high impact strength, low-molding cost are featured in the Borden's DURITE phenolic used in this washing machine agitator.



Self-lubrication, high mechanical strength and good finish are special properties of the Borden's DURITE phenolic used in this caster.

High dielectric properties and general durability are special properties of the Borden's DURITE phenolic used in this distributor head.

New Materials and Equipment

stant wheel speed under varying loads, and to prevent stalling under heavy cuts, this new constant speed precision grinder is powered by a standard type, constant speed continuous duty 1/6 hp, 3450-rpm a. c. motor. Good, clean, precision toolroom or general production work is said to be performed equally well with this new unit.

Finishing Machine

Although particularly recommended for applications where requirements approach a precision grind operation, the new single spindle surface finishing machine manufactured by *Clair Manufacturing Co.*, 1033 S. Union St., Olean, N. Y., is also suitable for a wide variety of small metal products.

Actuated by an electrohydraulic system, the Model 206 uses a single spindle upon which a roll 40 in. wide can be mounted. Automatic hydraulic in-and-out stroke is adjustable from 0 to 24 in. with a maximum holding and working area of 24 by 38 in., while an air circuit provides float of buff at any predetermined uniform pressure.

New Plastics Injection Press

Designed to achieve mass production of smaller plastic parts at low cost, the new semi-automatic press being manufactured by *The Van Dorn Iron Works Co.*, 2685 E. 79th St., Cleveland 4, is said to mold practically all thermoplastics, including nylon.

Known as Model H-200, the press has a 2-oz capacity and a casting area of 20 sq in. Its operating cycle is as follows:

1. A sliding action gate with interlocking safety devices starts the cycle (6 per min).
2. Molds close by action of solenoid operated valves.
3. Injection and dwell are controlled by one of the timers mounted on the rear panel.
4. Center timer controls recharging of the heater.
5. The third timer controls the length of the mold close cycle, and when time runs out, molds open and parts are ejected.

(*Continued on page 121*)

New Materials and Equipment

6. The operator opens the safety gate, removes the finished product, and closes the gate to begin the next cycle.

According to the manufacturer, a job can be done on this 79- by 26 by 58-in. press by one man in 20 min. Operating costs are said not to exceed more than $1. for 8 hr.

Electric Magnetic Chuck

Continental Electric Co., 1234 S. Prairie Ave., P. O. Box 89, Hawthorne, Calif., has announced the design of a new electric magnetic chuck, which has unusually strong holding power, for use on lathes. Work is said to be held to the chuck's surface by magnetic force with a total pull of over 2 tons.

Because of Model C's magnetic properties, it can be used for many new setups requiring heavy cuts on lathe work which previously were not practical.

According to the manufacturer, the new chuck can be used effectively in three ways: As a

1. Magnetic chuck
2. De-magnetizer
3. Magnetic inspection tool, to inspect small parts for cracks that are not ordinarily visible.

Available as a unit complete with a control box that plugs in wherever 115-v, 60-cycle current is available, the chuck itself plugs into the control box which has two switches, one for energizing the chuck's surface, and the other for demagnetizing it.

Testing & Control

Carbon Detection Apparatus

Savings up to 75% in the time required for determining carbon in steel are said to be possible by the use of the new Fisher induction carbon apparatus manufactured by *Fisher Scientific Co.*, 717 Forbes St., Pittsburgh 19.

According to the manufacturer, carbon determinations can be made routinely with the new apparatus in 2½ min, as compared with the 10 min frequently required.

The new unit employs a quartz sample

New Materials and Equipment

holder and an induction-type coil which heats the sample with radio frequency energy. Also included in the assembly is a platinum wire catalyst for converting any carbon monoxide into carbon dioxide. Carbon dioxide formed by the ignition passes through an absorber to remove sulfur dioxide and then is absorbed in the carbon dioxide absorbent. Once the sample is weighed (the apparatus is designed to handle the full factor weight of 2.727 g) and placed in the quartz heating chamber, the combustion cycle is entirely automatic.

Operating on 230 v, 50 to 60-cycle a.c., the self-contained unit is expected to handle a wide variety of steel alloys with carbon contents ranging from 0.072 to as high as 5.10%.

New Pyrometer Equipment

New pyrometer equipment consisting of flush- or surface-mounted indicators, controllers and protectors, which is said to offer accurate temperature indication, close temperature control of industrial

This HP-3 pyrometer controller is part of a complete line of pyrometer equipment consisting of flush- or surface-mounted indicators, controllers and protectors.

processes, and protection for furnaces, ovens and kilns, has been announced by the Meter and Instrument Div., *General Electric Co.*, Schenectady 5, N. Y.

Designed for industrial applications, the instrument is claimed to have a calibrated accuracy within ¾ of 1% of full scale. A legible 7-in. scale, fitted with an anti-glare cover, indicates any change in temperature equivalent to 1/10 of 1% of full scale. Normal changes in humidity, ambient temperature and voltage have little effect on the exactness of control action.

The heart of the indicating instrument is a ¾-lb magnet, which provides higher flux density and allows larger air gaps than are found in most instruments, while the indicating device is a millivoltmeter that is connected to a thermocouple on the furnace or other heating equipment.

Type HP-3 controller provides on-off action of the final control element by either a relay, mercury switch, or a con-

Double Output...

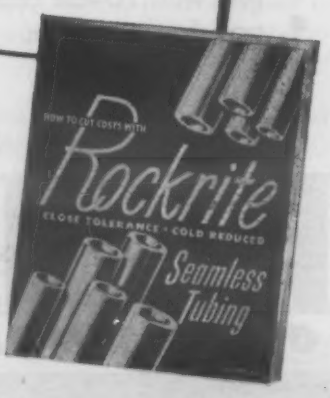
...of these parts by machining them from ROCKRITE® TUBING

Typical parts machined from Rockrite Tubing

Representing the extra production possible with Rockrite Tubing

TWO PARTS in the same time it takes to produce one! That's possible when you machine them from Rockrite instead of standard mechanical tubing. And you save up to 50% in cost. • The reasons? Rockrite Tubing is sized by a distinctively different process to much closer tolerances than are practicable by any other method. That means there's less metal to remove, and cutting speeds can be higher. Rockrite Tubing provides better work-surface finishes. Closer tolerances often eliminate the need to machine the inside or outside of the part. • What's more, tools last longer between grinds. Stations on automatics can often be released for additional operations. Extra long pieces are available, so there is less down-time for magazine stocking.

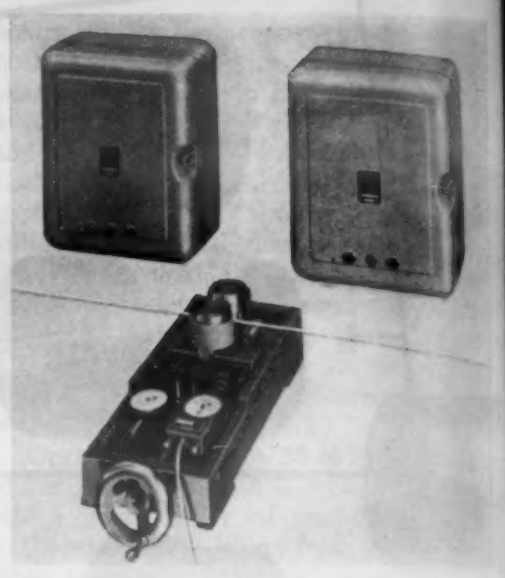
You'll want to read this booklet because it tells in detail how close-tolerance Rockrite Tubing, with its greater accuracy, helps step up production at less overall cost. Write for your copy of this 16-page, illustrated bulletin today.



ROCKRITE® TUBING

TUBE REDUCING CORPORATION · WALLINGTON, NEW JERSEY

New Materials and Equipment



This Model 493 B-80 wire measuring gage is said to save material by preventing excessive amounts from being deposited.

tactor through which electric power is supplied to the furnace or oven.

Used in conjunction with the HP-3, the pyrometer protector, a separate form of the HP-3, provides protection against possible failure of a separate precision controller.

Wire Measuring Gage

Federal Products Corp., 1144 Eddy St., Providence 1, R. I., has announced the design of a new continuous wire measuring gage, Model 493 B-80, that is said to automatically control the amount of material the extruder places on the wire.

Equipped to handle wire of any size up to 1-in. dia, the gage automatically speeds up or slows down the speed of the wire as it passes through the extruder.

A Federal Electricator is used in transferring the measurements to the speed control, while a second indicator is used in setting the gage. Actual diameter of the wire can be seen at any time. Signal lights also tell the operator when the coating is over or under size.

Ductility Tester

Designed to detect surface and sub-surface imperfections in deep-drawing steel over a comparatively large area, the new testing machine being manufactured by *Steel City Testing Machines, Inc.*, 8843 Livernois, Detroit 4, is said to provide a total capacity of 250,000-lb pressure.

Motorized, hydraulically operated, and

What's the *right* X-Ray film?

Product:
Gear housing

Material:
Magnesium

Thickness:
Walls varying $\frac{1}{4}$" to 1"

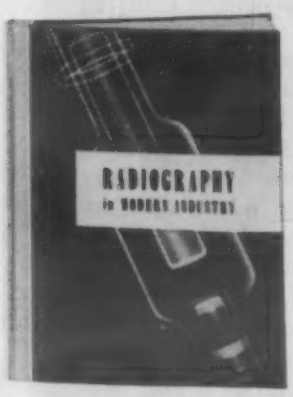
Equipment:
140-kv X-ray unit

ANSWER:

KODAK INDUSTRIAL X-RAY FILM, TYPE M

In a light alloy casting such as this, the radiographer is interested in discovering microporosity, as well as other irregularities that might be present. This requires the highest possible visibility of detail.

Therefore, Kodak Industrial X-ray Film, Type M, is chosen because this film has the highest contrast and finest graininess of all x-ray films.

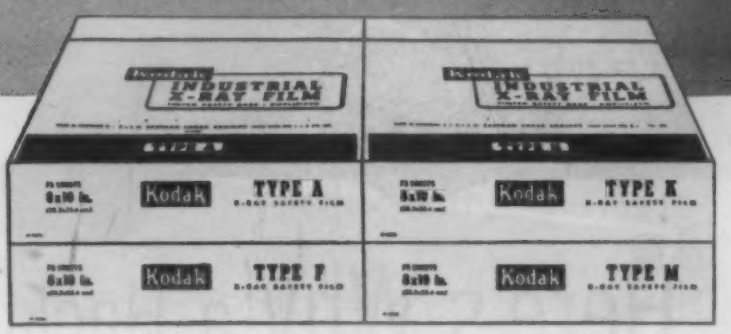


RADIOGRAPHY IN MODERN INDUSTRY

A wealth of invaluable data on radiographic principles, practices, and technics. Profusely illustrated with photographs, colorful drawings, diagrams, and charts. Get your copy from your local x-ray dealer—price $3.

Radiography . . .

another important function of photography



A TYPE OF FILM FOR EVERY PROBLEM

To provide the recording medium best suited to any combination of radiographic factors, Kodak produces four types of industrial x-ray film.

Type M provides maximum radiographic sensitivity, high contrast, and exceptional detail under direct exposure or with lead-foil screens. It has extra fine graininess, and the speed is adequate for examination of light alloys at average kilovoltage and for much million-volt radiography.

Type A offers high contrast with about three times the speed of Type M, but with slightly more graininess. Used direct or with lead-foil screens for study of light alloys at low voltages, and of heavy steel parts with 1000-kv x-rays or radium.

Type K has medium contrast with high speed. For gamma ray work and for x-ray work where highest possible speed is needed at available kilovoltage without use of calcium tungstate screens.

Type F provides the highest available speed and contrast when exposed to x-rays with calcium tungstate intensifying screens. Has wide latitude with either x-rays or gamma rays, exposed directly or with lead-foil screens.

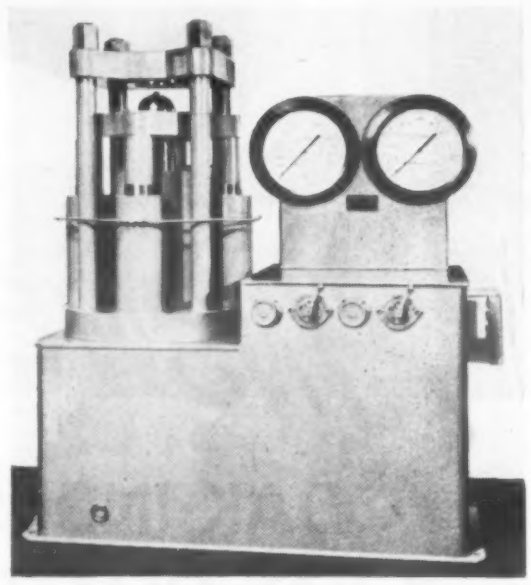
EASTMAN KODAK COMPANY
X-ray Division · Rochester 4, N. Y.

Kodak
TRADE-MARK

New Materials and Equipment

equipped with a set of three dies for use with different metal gages, the machine is reported to test material up to ¼-in. thick. Penetrating pressure can be applied up to 150,000 lb, while stamping pressures are provided up to 100,000 lb.

An outstanding feature of this machine is its 5-in. dia penetrator, which affords a greater opportunity for detecting surface and sub-surface imperfections. To aid in the evaluation of results, the area involved in the test is inscribed with a 1-in. grid which can be correlated to the grid pattern of drawn parts.



This new ductility tester is designed to detect surface and sub-surface imperfections in deep-drawing steel over a large area.

Automatic Furnace Control

Development of a time cycle reversal system, a unit for the automatic control of open-hearth furnace firing, has been announced by *Bloom Engineering Co., Inc.*, 857 W. North Ave., Pittsburgh 12.

Among the advantages said to be secured through the use of this pre-wired, self-contained unit are savings in fuel, longer life of checkers, increased steel production, and greater flexibility in furnace operation.

Furnace reversal is said to be completed smoothly and quickly (9 to 10 sec) and, after firing, the furnace is again reversed. All reversal operations are performed in proper sequence on a pre-determined cycle without any help from the operator, who can change the timing or revert to manual operation by the touch of a control button.

New Tinnerman CAP NUT

—zips over shafts and studs

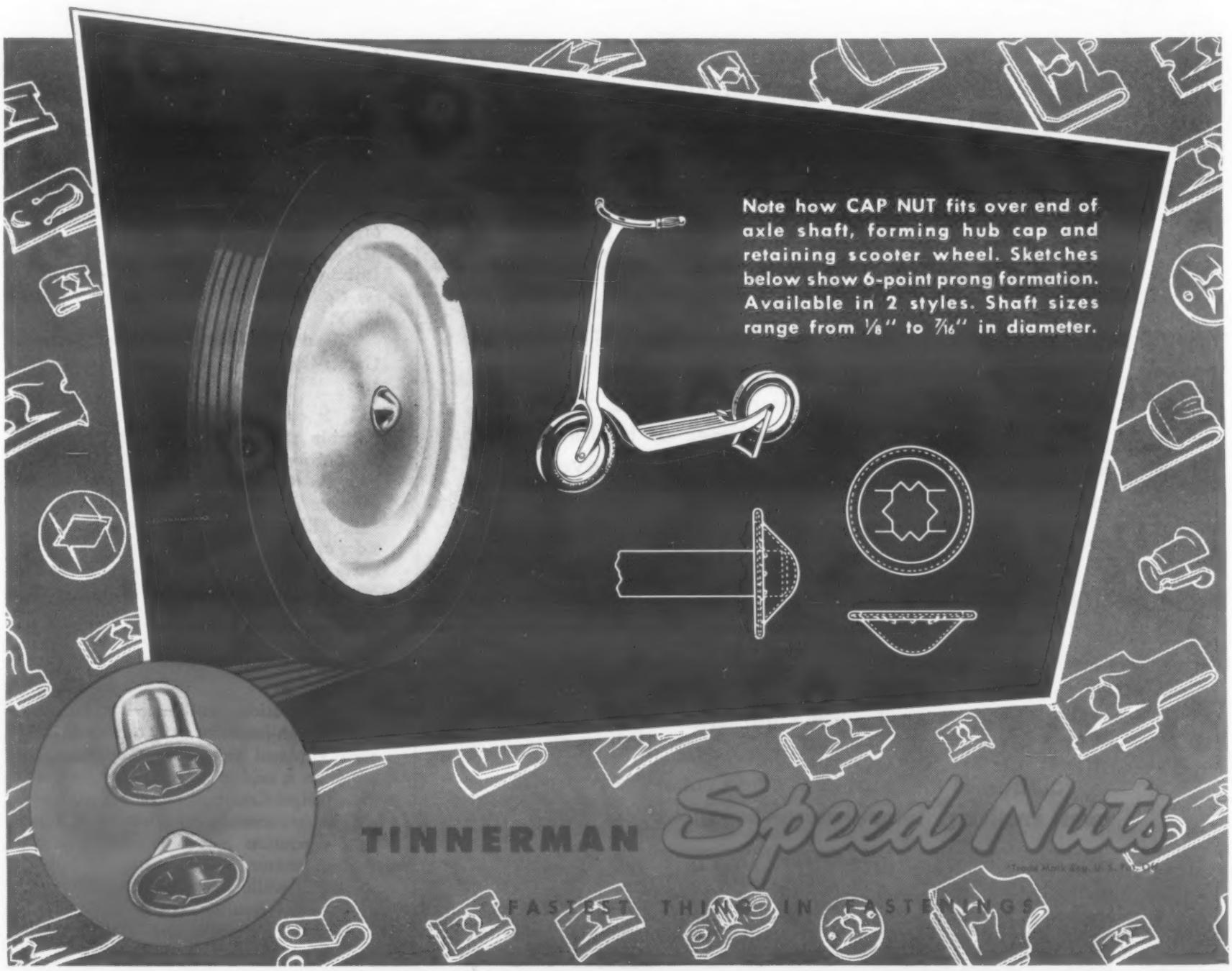
for secure decorative attachments

Never before a fastener that performs better in retaining and capping shafts, axles or stud ends! A new push-on type SPEED NUT is here to improve your assembly methods.

It has already proved itself by short-cutting expensive assembly steps for manufacturers of wheel goods and toys. You can readily see why if you compare the simple Cap Nut attachment to the intricate cross-drilling of axles, securing cotter pins, and attaching split hub caps.

Think of your product as you check these advantages: (1) single unit assembly; (2) zip over shaft—lock tight—no special tools required; (3) six contact points of SPEED NUT bite into shaft; (4) provides decorative, protective cover for shaft ends.

For expert technical assistance in adapting the new CAP NUT to your use, call in your Tinnerman sales engineer. Meanwhile, write for 32-page Savings Stories booklet of case histories. TINNERMAN PRODUCTS, INC., Box 6688, Dept. 12, Cleveland 1, Ohio. In Canada: Dominion Fasteners Ltd., Hamilton. In Great Britain: Simmonds Aerocessories, Ltd., Treforest, Wales.



New Materials and Equipment

Wire Strain Gage

A new type of SR-4® bonded resistance wire strain gage, self-compensated for temperature variation, has been announced by *Baldwin Locomotive Works,* Philadelphia 42.

Available for use on Dural and steel in the form of single and double elements and rosettes, the new gage is said to eliminate a second strain gage to compensate for temperature changes, thus saving application time and wiring.

Basically, the new gage is similar to standard Bakelite gages with cupro-nickel wire, and its application is by means of the same methods and phenol-resin cement.

Gages for two temperature ranges are offered: 50 to 300 F and -50 to +300 F. Single element gages for Dural or steel are available in four gage lengths: 1/4, 3/8, 13/16 and 7/8 in., while double elements and rosettes are available on special order.

Tin Thickness Gage

A new electronic thickness gage for the quick, accurate and economical gaging of tin coatings on ferrous stock has been developed by the Research and Control Instruments Div. of *North American Philips Co.,* 750 S. Fulton Ave., Mt. Vernon, N. Y.

Advantages claimed for the Norelco Geiger-Counter tin plating thickness gage are:

1. It conserves critical tin by making possible the maintenance of continuous satisfactory coatings.
2. As the test sheet can be used in the ultimate product, there is no wastage.
3. Thicknesses can be checked on both sides of a sheet simultaneously, and a point check can be determined in approximately 30 sec. Thicknesses from 10 to 120 micro-in. can be determined to within about 2% accuracy.
4. Sheets up to 39 in. in width can be checked.

In operation, collimated x-radiation from a high-intensity x-ray tube is directed onto a plated test sheet. The emergent radiation is said to be accurately measured by a Geiger-Counter, which operates suitable electro-mechanical printed tape registers. Operation is comparatively simple, as the operator merely inserts and indexes the sheets while the printing tape registers indicate the results.

Available as single and dual units, the

(*Continued on page 132*)

OVER 50 YEARS OF

Specialization

IN STRIP STEELS

STAINLESS

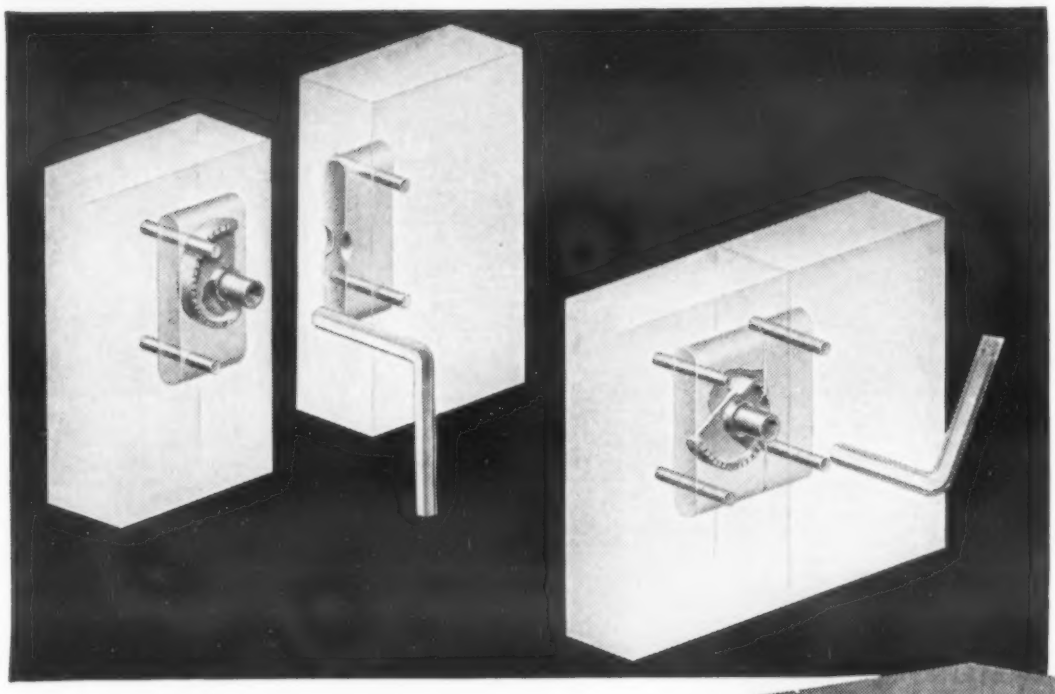
SPRING STEELS

CLAD METALS

ALLOYS

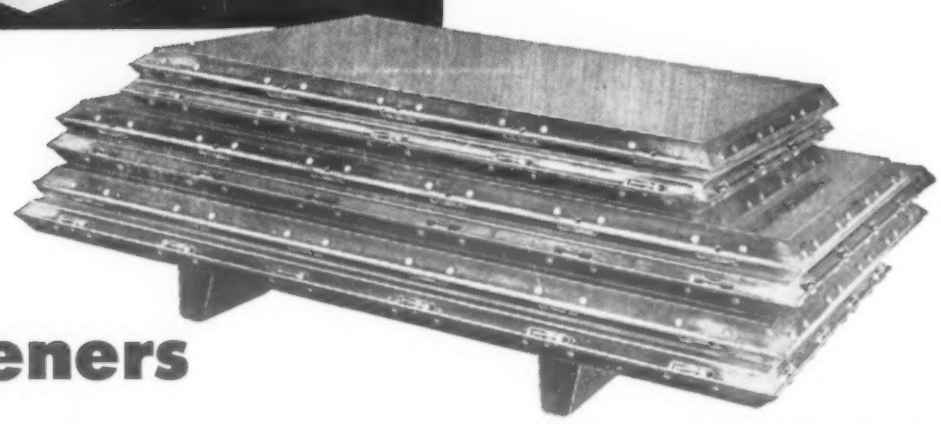
Specialization, in the fundamental Superior way, extends throughout our plant facilities, our research and our manufacturing techniques . . . to the sole end of producing finer strip steels for our customers. Our new plant installations, —including the Hot Mill shown above, cold rolling mills, and strip handling and storing facilities—signify faster, better service over a wider market range. • Let us detail the benefits to *you* of Superior specialization!

Superior Steel
CORPORATION
CARNEGIE, PENNSYLVANIA



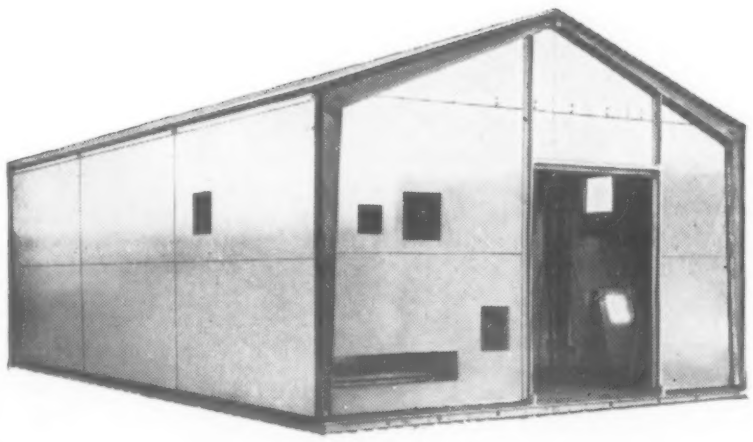
Serrated, tapered cam in male component engages lip of female. Panels are drawn tightly together when cam is turned by hex wrench, screwdriver, or any hand tool.

Lightweight air transport shipping containers, with Roto-Lock Fasteners, knock down quickly for easy return shipment.



PHOTO, COURTESY UNITED STATES PLYWOOD CORPORATION

New Roto-Lock Fasteners Solve Demountable Panel Problems



This portable shelter is made of honeycomb panels developed by the U. S. Plywood Corporation. All panels are attached with Simmons Roto-Lock Fasteners. Portable buildings are also being planned for alert hangars and maintenance hangars for fighter aircraft.

Panels of any material—equipped with the new Simmons Roto-Lock—can be fastened quickly and securely either at right angles or butt joint. No skill is required—just turn the tapered cam to lock, then turn again to unlock. Check these features of Roto-Lock...

1. Roto-Lock exerts sufficient pressure to form airtight and watertight seal when gaskets are used between panels. Carries high-tension loads as well as heavy shear loads—providing a completely structural, insulated connection.
2. Recesses completely into panels—no protruding parts.
3. Will fasten in seriously misaligned conditions—locks in any semi-open position.
4. No springs or delicate mechanical parts which may be affected by severe temperature conditions or field service.

Portable shelters, air freight and cold-storage shipping containers, walk-in coolers, demountable furniture, scaffolding, and many other designs where demountability is desirable, are using this versatile fastener. All are illustrated in our literature. Write for your copy today.

Simmons Fastener Corporation
1759 NORTH BROADWAY, ALBANY 1, N. Y.

QUICK-LOCK...
SPRING-LOCK...
ROTO-LOCK...

Here we are again...

Radio people turned radar specialists . . . washing machine makers now making fire control devices . . . and the rest of us doing what has to be done — we're in the same boat.

we have converted to fill your needs for

SPONGEX *cellular rubber*

For insulation against the transmission of shock, sound, vibration and the passage of dust, air, temperature and moisture.

SPONGEX *cell-tite**

Closed cell rubber, hard or soft. For insulation, flotation, space filling and sandwich construction.

*Spongex and Cell-Tite are our registered Trade Names

Sheets,
cord and strip;
die-cut shapes and
custom molded forms.

SPONGEX *silicone*

The cellular rubber that works at extremes of temperatures as high as 500° F or as low as —130° F.

PARTICIPATING IN THE MANAGEMENT AND FINANCING OF KENTUCKY SYNTHETIC RUBBER CORPORATION

The World's Largest Specialists in Cellular Rubber

THE SPONGE RUBBER PRODUCTS COMPANY

403 DERBY PLACE, SHELTON, CONN.

New Materials and Equipment

electronic apparatus is self-contained and designed for operation on 200 to 240 v, single-phase 60 cycles (50-cycle equipment on special order). Power consumption is 3 kva for the single unit and 5 kva for the double.

General

Universal Camera Microscope

Originating in Austria, the new Reichert universal camera microscope for metallurgical work now being distributed by *William J. Hacker & Co., Inc.*, 82 Beaver St., New York 5, is said to be the most compact and easy to operate equipment of its kind.

Outstanding features of the new Model MeF are said to include:

1. A built-in camera and a magnification of from 4.5 to 2200 times.
2. Instant change-over from bright to dark ground illumination.
3. Instantaneous transition from visual observation to photography and from ordinary to polarized light.

Methods of illumination are vertical (bright-ground), oblique internal (bright-ground), flat oblique multilateral (dark-ground), and unilateral external (dark-ground).

New Impregnating Equipment

Designed for the smaller foundries and manufacturers to solve leaker problems in small parts and castings, the new piece of impregnating equipment announced by *Tincher Products Co.*, 872 Borden Ave., Sycamore, Ill., is said to seal pressure castings rejected because of porosity.

According to the manufacturer, a part or casting once sealed is pressure tight for the life of that part, and an impregnated casting will withstand any pressure, temperature and chemical condition for which the part was intended.

Both ferrous and nonferrous metals can be sealed by this effective and economical process which uses a noninflammable, nontoxic sealant. No baking or curing process is required other than a 24-hr setting period.

Another new development using

B. F. Goodrich Chemical Company ***raw materials***

NEW IDEA IN OIL FILTERS

Oil filter by PurOlator Products, Inc., Rahway, N. J.

B. F. Goodrich Chemical Co. does not manufacture this gasket. We supply raw materials only.

—a re-usable *Hycar* **GASKET!**

IDEA-MEN are always finding some new sales-making use for Hycar—like the gasket for a new type oil filter pictured here. Because of Hycar's many advantages over materials formerly used, this gasket can be used over and over—whenever the filter is replaced. Permanency of seal and retention of oil are *assured!*

For use in parts that must withstand oil, gasoline and other deteriorating fluids, Hycar can be compounded to provide low absorption. Yet, it remains practically unchanged in hardness, elongation and tensile strength even after prolonged exposure.

Excellent resistance to cold flow and compression set are characteristic of Hycar compounds. They exhibit good flex-life and have extreme resistance to oxidation and aging.

What Hycar does for this gasket may give you an idea for improving or developing a product. Any one, or combination of Hycar's advantages—resistance to oil, gas, heat and cold, weather and wear—may be just what you need. We make no finished products—supply raw materials only. But our staff is always ready to help you with technical service. Just write Dept. HM-1, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, O. Cable address: Goodchemco.

B. F. Goodrich Chemical Company

A Division of The B. F. Goodrich Company

Need extreme temperature resistance? Hycar has it—plus abrasion resistance and more advantages

Hycar

Reg. U. S. Pat. Off.

American Rubber

See Sweet's File for Product Designers, Materials Section, for further data on Hycar.

GEON polyvinyl materials • HYCAR American rubber • GOOD-RITE chemicals and plasticizers

Powder Metallurgy Can Help Conserve Critical Metals

by A. J. LANGHAMMER,
President, Amplex Manufacturing Co.

• THE CONSERVATION OF strategic metals is one of the most serious problems that confronts industry at this time. Thus, industry is viewing with increased interest the important role that powder metallurgy can play in present and future mass-production plans. Finished machine parts, bearings and other units can be replaced by metal powder products, not only for strategic materials but also for those of ferrous base, including cast iron and steel.

The prime reason why this transition may be effected is the availability of iron powder. Because this material is largely made from waste products, or other raw materials available in sufficient quantity, it is not controlled.

Aside from making finished machine parts available for replacement of units now being produced from other materials, powder metallurgy offers several other advantages. For example, no machine tools, tooling program, jigs, fixtures, dies and gages are required. Generally, there is also an effective saving in manpower and speed of delivery. Tooling for powder metallurgy is more quickly accomplished than by normal production methods. Moreover, this advantage increases rather than decreases as the finished machine part has added details or becomes more complicated.

Briefly, metal powder parts are made by pressing (or briquetting) the metal powder to size and dimensions, then heat treating (sintering) without the briquette losing its form or shape. Briquetting is accomplished on automatic machines and in one operation. After sintering, the parts may or may not be given a sizing operation, and this, too, is performed in one stroke of a press. In a vast majority of cases, no machining is required; therefore, there is little scrap.

Finished Machine Parts

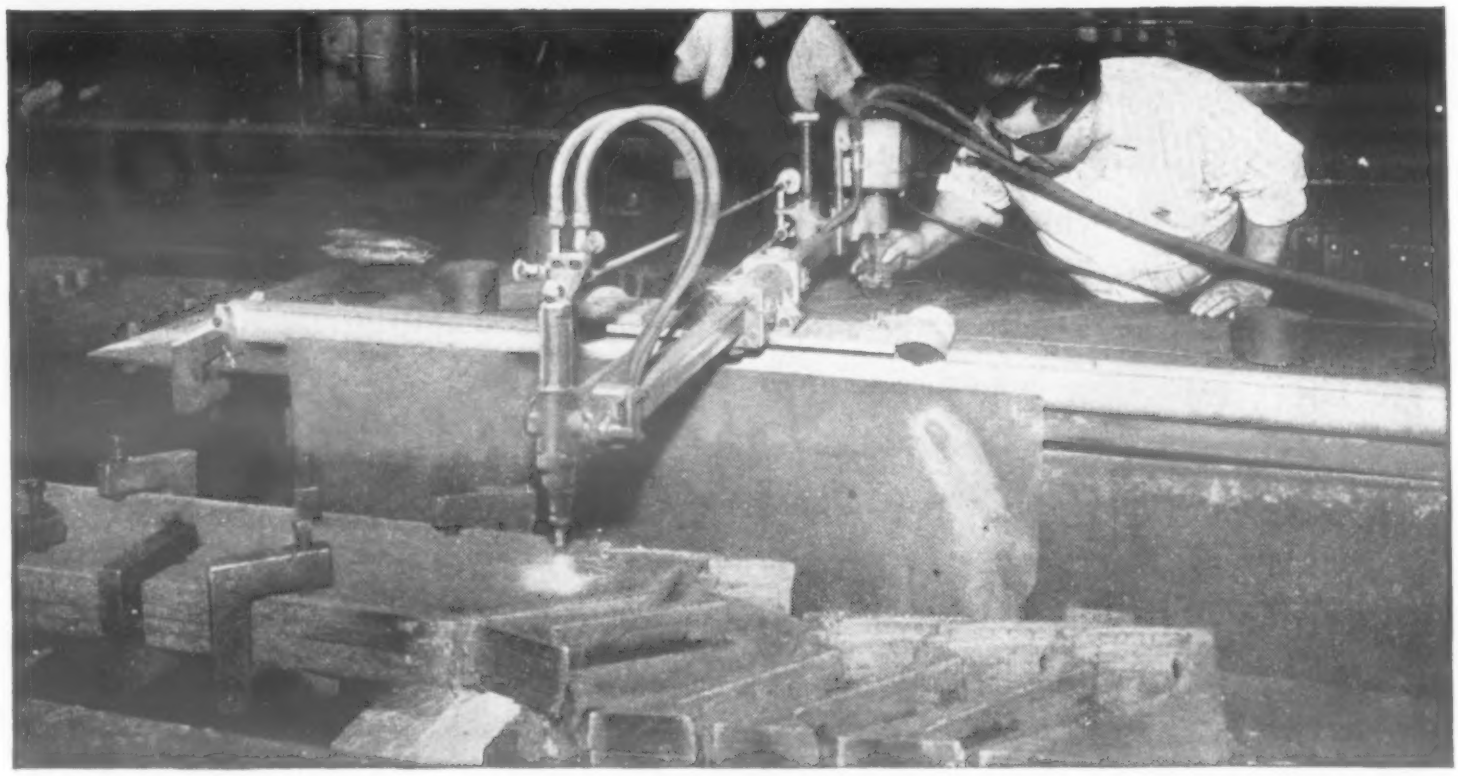
Finished machine parts of metal powders today cover a wide range

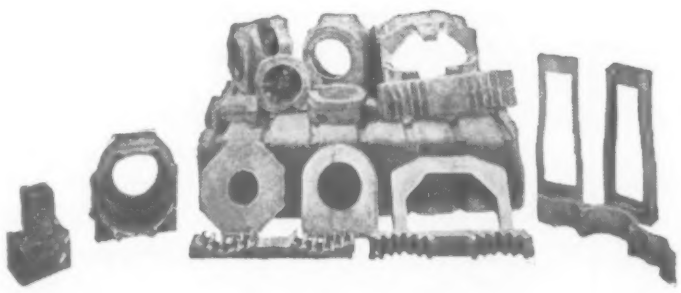
(*Continued on page 136*)

NOW

A GAS SHAPE CUTTING MACHINE

THAT IS: *1. low-priced*
2. portable
3. accurate





AIRCO AIR REDUCTION

AIR REDUCTION SALES COMPANY • AIR REDUCTION MAGNOLIA COMPANY
AIR REDUCTION PACIFIC COMPANY
REPRESENTED INTERNATIONALLY BY AIRCO COMPANY INTERNATIONAL
Divisions of Air Reduction Company, Incorporated
Offices in Principal Cities

That's a statement that is 100% true! In one shop they found this new machine—the AIRCO No. 3 MONOGRAPH—excellent for shape cutting the 1001 odd jobs that constantly came up!

In fact, they have cut more than 16,000 drop-floor hinges alone—stack cutting them from mild steel plate, as shown above. This one operation saved more than the price of the machine. In addition, they cut hundreds of other parts—body center plate blanks, engine truck roller racks, spring hangers, pipe clamps and many others.

The NEW Airco No. 3 Monograph will handle practically any cutting job—straight line, circle, or bevel, in addition to angles, curves and other ordinary shapes. It can be used stationary or portable, as the occasion demands.

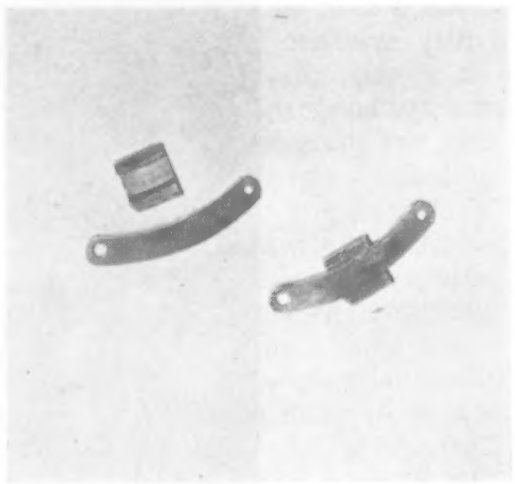
This NEW machine, lowest priced of its type on the market (only $695, including a manual tracing device, torch, tip, tubular rail, hose and carrying case), will cut steel up to 8 inches thick. Its cutting area is 32 inches by 56 inches, and with the addition of sections of 6-foot, 8-inch tubular rail, the length of the cutting area can be extended as desired.

SPECIAL TRIAL OFFER
(Good in Continental U.S.A. Only)
If you would like to try this machine for two weeks in your own shop on your own work, just drop a letter to your nearest Airco office, and they will advise you how this can be arranged . . . or, if you would like a descriptive folder (ADC-660), they will be glad to send you one.

continued from page 134

of design and application. In our production, as an example, we fabricate such units as pistons, guides, sleeves, housings, cams, gears, sprocket wheels, ratchets, plates, gibs and bases, which are used in such industries as machine tools, special machinery, factory equipment, automotive, farm implements, textile, toys, conveyors, household appliances, engines, ships, etc.

Equally broad is the range of size in which these finished machine parts



This bar and slide unit made from metal powders produced savings of 65¢ on the bar and $1.25 on the slide, when compared to cost of production by standard machining methods.

are made. In mass production quantities they vary from several hundred units to the pound to parts that weigh 2 to 3 lb each. Where smaller quantities are required, units are frequently much larger in size. They may range in weight from 10 lb to more than 200 lb each.

An accompanying photograph illustrates a bar and slide unit, for a special machine, now being produced by powder metallurgy methods. When these two parts were made by normal machining methods, the cost of the bar was $0.70 and the slide cost $1.30. Made from metal powder, these parts now cost only $0.05 and $0.06, respectively. Such reductions in cost of manufacture are typical of our experience.

Another photograph shows another example of the application of finished machine parts made from metal powders. In each pair, the part to the right is made of metal powder which replaced, at considerable saving, the unit of cast iron which was only rough snagged, not machined.

(*Continued on page 138*)

ENGINEERING AID

on large and heavy

CARBON AND ALLOY

STEEL CASTINGS

CONTINENTAL . . . as a major designer and builder of rolling mills and heavy machinery requiring hundreds of tons of castings yearly . . . *knows* the engineering of castings for economical production and dependable performance. CONTINENTAL is prepared to provide this service when you require engineering assistance.

6 GOOD REASONS
to see CONTINENTAL

1. Ideal Shipping Locations
2. Ample Foundry Facilities
3. Large Scale Machine Shops
4. Complete Heat Treating
5. Experienced Casting Engineering
6. Modern Quality Control

Continental

CASTINGS: Carbon and Alloy Steel; from 20 to 250,000 pounds.

ROLLS: Iron, Alloy Iron and Steel; for All Types of Rolling Mills.

MILLS: Complete Rolling Mill Installations and Auxiliary Equipment.

Continental

FOUNDRY & MACHINE CO.

CHICAGO · PITTSBURGH

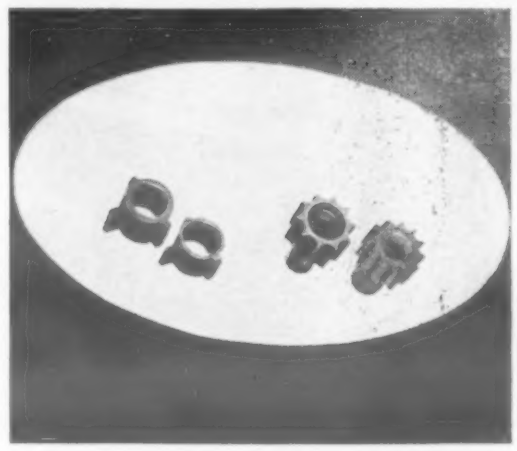
Plants at: E. Chicago, Ind. • Wheeling, W.Va. • Pittsburgh, Pa.

continued from page 136

Other advantages included easier and quicker assembly, a smoother and practically noiseless machine.

Other Advantages

On any unit where motion occurs, powder metallurgy provides the indispensable and otherwise unobtainable feature of self-lubrication. Moreover, many of these products are precision units manufactured to close tolerances.



In each of these illustrations, the unit to the left is of cast iron, not machined. Produced by powder metallurgy methods, the part to the right is finished without need for further machining and provides easier and quicker assembly, is a smoother and practically noiseless mechanism.

Where weight is a factor, there is saving in weight with metal powder parts. Normally, powder metal units have a porosity of approximately 25% by volume. Therefore, an appreciable advantage in terms of weight can be achieved without changing from a basic material. Of course, if some metal such as aluminum is used, there is that added weight advantage due to porosity.

Since the normal porosity value is the order of 25%, any unit made from metal powders of the same material as used in the solid must be at least 25% less strong. However, for any given metal or alloy if high strength is required this, too, may be effected by special processing. In laboratory practice we have equalled the properties of the solid or cast materials.

With regard to the strength, we have found that the specifications are not necessarily correct. For example, if a part is made from cold rolled steel bar stock or cold rolled sheet

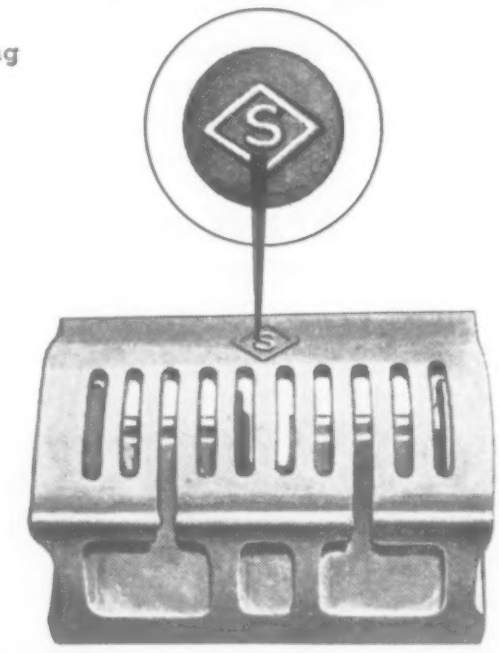
(*Continued on page 140*)

if Michelangelo were alive . . .

. . . he would probably consider the technical and metallurgical perfection of Sivyer castings as a work of art. A foundryman of no mean ability . . . he would be quick to recognize the craftsmanship of Sivyer methods . . . the know-how and precision with which a wide variety of complicated castings are produced. Sivyer insistence on the highest standards of compositional accuracy—uniformity of internal structure, dimensional accuracy and good finish means lower costs—better performance. It will pay you to consult Sivyer on your steel casting problems.

the HALLMARK of better steel castings

Sivyer castings are identified with the famous Ⓢ marking —your assurance of the finest in high alloy and specification steel castings.



SIVYER

SPECIALISTS IN HIGH ALLOY AND SPECIFICATION STEEL CASTINGS

SIVYER STEEL CASTING COMPANY • MILWAUKEE Ⓢ CHICAGO Ⓢ

continued from page 138

steel, some engineers automatically apply the specifications of that material. However, strength as low as 25% of these materials may be satisfactory. When physical properties are compared, it is recommended that the required strength rather than a former specification be considered. The American Society for Testing Materials has a set of standards regarding products of powder metallurgy, but, as indicated, special properties beyond the limits of the said specifications may be obtained.

Tooling for powder metallurgy is not nearly as expensive when compared to that of normal manufacturing methods. Invariably, the latter employ jigs, fixtures, cutting tools, and, sometimes, finishing operations which are definitely more costly. Also, the time interval required in the latter case is much longer since patterns, castings and forgings are usually involved.

Some of our tools cost as low as $150.00 per set, and approximately $400.00 would be the average cost. On the other hand, we have made special tools that cost several thousand dollars but, even in these instances, the amount was considerably less than that which would have been required for normal machining.

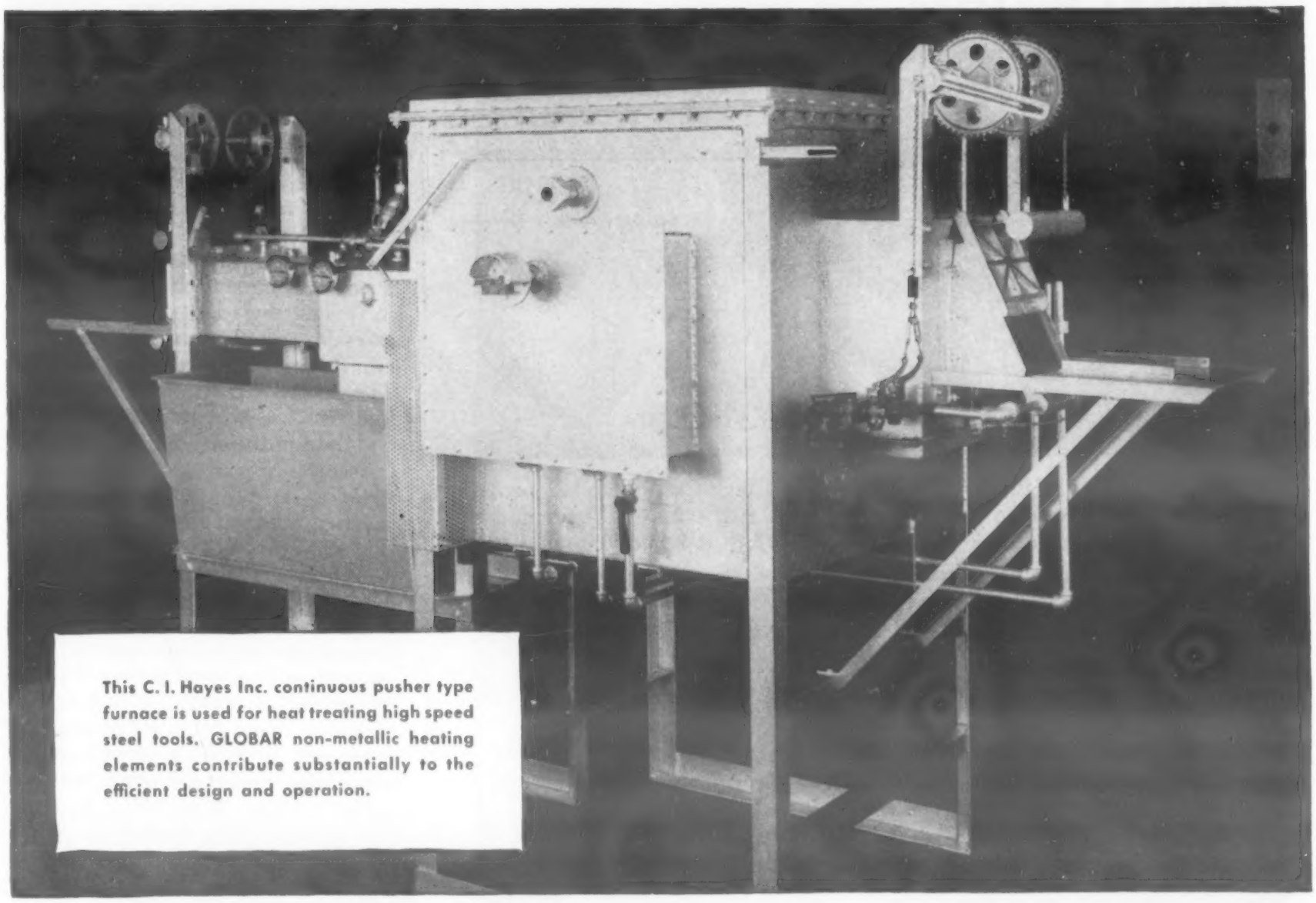
Often, there are misconceptions about the quantities which are required to make a part profitably by powder metallurgy. In our experience we have found that the quantity actually required is frequently much lower than originally anticipated. In general production, a good average figure would lie in the range of 2,000 to 10,000 pieces, although quantities exceeding 100,000 are not at all uncommon. However, small quantities can be produced on special requirements, by hand or so-called laboratory methods. While the manufacture of finished machine parts from metal powders is particularly suited to mass production, its advantages apply equally well in many instances where the quantities needed are appreciably lower.

Obviously, too, there are many applications for which there is no satisfactory substitute for the powder metal product. This applies where self-lubrication is necessary. It is also true where specific weight is a consideration; where definite friction properties are required; and when other factors are present, such as those which pertain to permanent filtering.

GLOBAR elements used in HAYES Furnace to assure

DEPENDABLE SERVICE

during peak loads



This C. I. Hayes Inc. continuous pusher type furnace is used for heat treating high speed steel tools. GLOBAR non-metallic heating elements contribute substantially to the efficient design and operation.

GLOBAR silicon carbide heating elements provide an ample margin of safety at the normal operating temperature of this heat treating furnace. Peaks in production are handled without danger of costly breakdowns. Dependable performance and low maintenance cost on regular production schedules are assured. Simplicity of furnace design and construction provide fast, simple element installation . . . even while the furnace is at temperature. Heating is clean, silent and safe.

For more detailed information on the installation and operation of GLOBAR non-metallic heating elements, write Dept. W-21, The Carborundum Company, GLOBAR Division, Niagara Falls, New York.

GLOBAR Heating Elements

BY CARBORUNDUM

TRADE MARK

"Carborundum" and "Globar" are registered trademarks which indicate manufacture by The Carborundum Company

Lead-Bearing Steel Improves Machinability

by HENRY J. HOLQUIST,
Joseph T. Ryerson & Son, Inc.

● FOR MANY YEARS there have been demands for steels which would combine the good qualities of open hearth steel with easy machinability. It was generally recognized that the addition of lead lowered the friction component of steel in machining and reduced the amount of heat developed in the cutting edges of tools, thereby extending tool life and greatly lengthening the time between grindings. The problem, however, when adding lead to steel, was to secure uniform distribution throughout the steel with no segregation of lead to form soft spots.

After long, continued research by Inland Steel Co., a steel containing 0.25% lead was developed in which the lead was so finely dispersed that it could not be seen under a microscope. In addition, the presence of the lead resulted in the steel having a slight refinement of grain, but had no appreciable effect upon its mechanical properties. In 1938, it was placed on the market under the trade name of Ledloy. During World War II, however, production of Ledloy for peacetime uses was greatly curtailed, and only within the past few years has production been resumed.

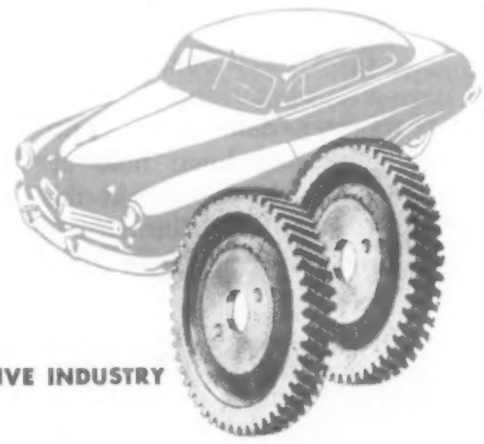
Considerable interest in Ledloy is being shown in the highly competitive business of making screw machine products where fractions of a second per piece cut from production time can spell the difference between profit and loss. On the basis of comparative demonstrations in jobbing shops, Ledloy has shown many advantages over AISI B-1113 Bessemer sulfurized carbon steels which, for many years, have been accepted as the fastest cutting screw steels available.

Ledloy machines up to 50% faster than B-1113 and allows greatly increased tool life, while retaining such advantages of open hearth quality steel as good ductility, high impact values, good transverse strength, and effective case hardening qualities. When carburized in the box at 1700

(*Continued on page 144*)

When you want advantages no metal can give you

micarta is basic!



AUTOMOTIVE INDUSTRY

There are millions of automobiles using MICARTA timing gears on the road today. The gears can be fabricated to match the famous mass production of the auto industry. The versatility of MICARTA as a basic material creates a place for it in all industries. Explore its uses.

Start with MICARTA®. It can't rust . . . won't liquefy under heat or pressure . . . makes an ideal insulator. It is a solid and workable plastic material which does many jobs better than metal.

Here is a basic material even lighter than aluminum. And pound for pound, its compressive strength is greater than structural steel. It can be machined, formed or fabricated easier and more economically than metal.

When the design calls for a better basic material, look into MICARTA. You may have a place where you need the advantages no metal can give you. Westinghouse Electric Corporation, Micarta Division, Trafford, Pennsylvania. J-06445

Lead-Bearing Steel

continued from page 142

F, the case hardness and depth of case approximate that of the open hearth high manganese, high sulfur steels. Furthermore, the mechanical properties of Ledloy, from heat to heat, are more consistent than those of B-1113.

Typical of the performance studies of Ledloy were those made at the plant of Milled Screw Products Co., Chicago, a 100% jobbing shop, operating some 83 Brown and Sharpe automatic screw machines, other machine tools, and a complete hand screw machine department. The first

Production of plungers, one of which is being formed here, increased 36.3% when Ledloy was substituted for previously-used AISI B-1113.

study covered production of a plunger approximately ¾ in. long and made from ½-in. stock. Using a Brown and Sharpe No. 0 Automatic, the operations (in sequence) are: center, drill, ream, form and cut-off. The step-down hole at the formed end is ⅛-in. dia; at the cut-off end, 1/16-in. dia. Comparisons of machining time and speed follow:

B-1113	*Ledloy*
Surface Feet per Minute	
210	294
Time per Piece, Total Operation	
25 sec	18⅓ sec

Of course, these figures, indicating a 40% increase in surface ft per min and a 36.3% increase in production, do not reflect increased production per machine hour due to longer tool life. Not only was a tool life five times as great secured, but also fewer rejections and a better finish.

Another study covered production of an adjustment plug made from ½-in. stock and approximately ⅞ in. long. Using a Brown and Sharpe

(*Continued on page 146*)

Buehler . . .

. . . OFFERS A COMPLETE LINE OF EQUIPMENT FOR THE Metallurgical Laboratory

Buehler specimen preparation equipment is designed especially for the metallurgist, and is built with a high degree of precision and accuracy for the fast production of the finest quality of metallurgical specimens.

1. No. 1315 Press for the rapid moulding of specimen mounts, either bakelite or transparent plastic. Heating element can be raised and cooling blocks swung into position without releasing pressure on the mold.

2. No. 1211 Wet power grinder with 3/4" hp. ball bearing motor totally enclosed. Has two 12" wheels mounted on metal plates for coarse and medium grinding.

3. No. 1000 Cut-off machine is a heavy duty cutter for stock up to 3-1/2". Powered with a 3 hp. totally enclosed motor with cut-off wheel, 12" x 3/32" x 1-1/4".

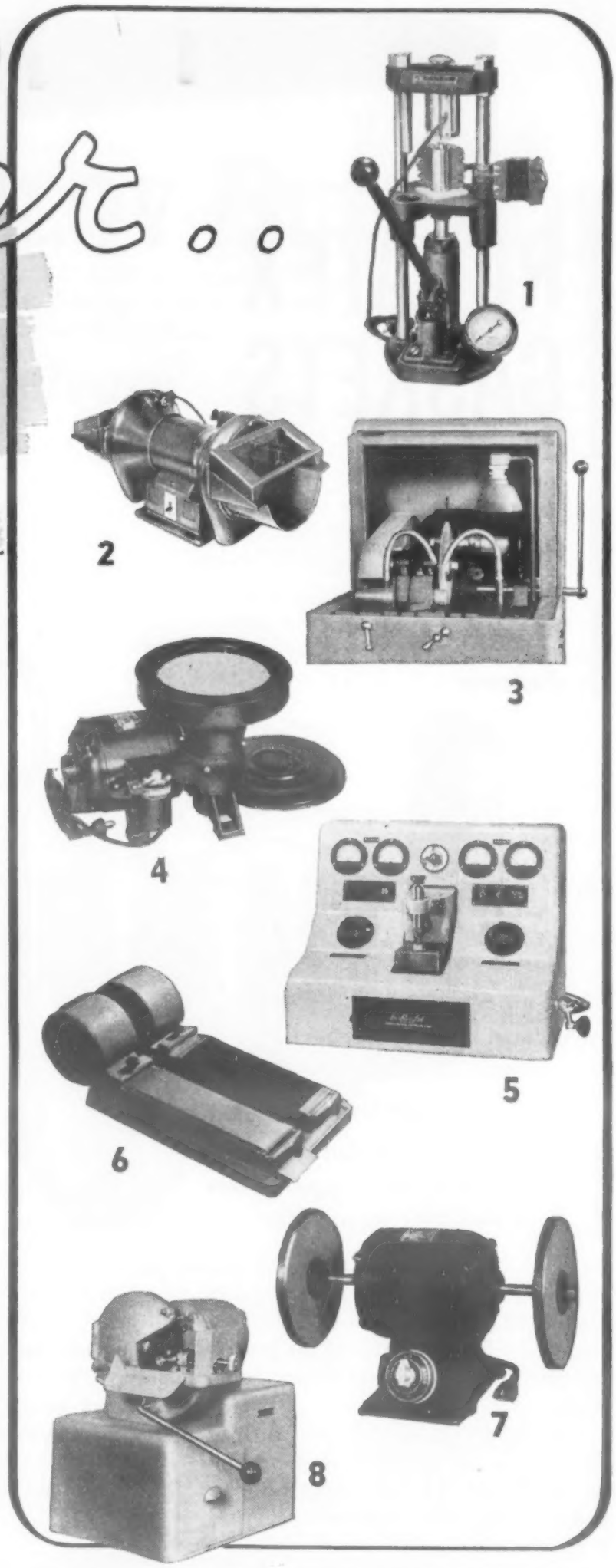
4. 1505-2AB Low Speed Polisher complete with 8" balanced bronze polishing disc. Mounted to 1/4 hp. ball bearing, two speed motor, with right angle gear reduction for 161 and 246 R.P.M. spindle speeds.

5. No. 1700 New Buehler-Waisman Electro Polisher produces scratch-free specimens in a fraction of the time usually required for polishing. Speed with dependable results is obtained with both ferrous and non-ferrous samples. Simple to operate—does not require an expert technician to produce good specimens.

6. No. 1410 Hand Grinder conveniently arranged for two stage grinding with medium and fine emery paper on twin grinding surfaces. A reserve supply of 150 ft. of abrasive paper is contained in rolls and can be quickly drawn into position for use.

7. No. 1400 Emery paper disc grinder. Four grades of abrasive paper are provided for grinding on the four sides of discs, 8" in diameter. Motor 1/3 hp. with two speeds, 575 and 1150 R.P.M.

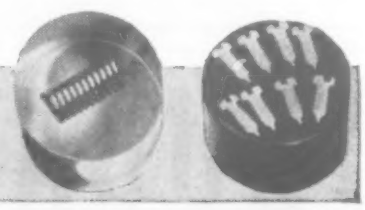
8. No. 1015 Cut-off machine for table mounting with separate unit recirculating cooling system No. 1016. Motor 1 hp. with capacity for cutting 1" stock.



THE BUEHLER LINE OF SPECIMEN PREPARATION EQUIPMENT INCLUDES . . . CUT-OFF MACHINES • SPECIMEN MOUNT PRESSES • POWER GRINDERS • EMERY PAPER GRINDERS • HAND GRINDERS • BELT SURFACERS • MECHANICAL AND ELECTRO POLISHERS • POLISHING CLOTHS • POLISHING ABRASIVES

Buehler Ltd.
A PARTNERSHIP

METALLURGICAL APPARATUS
165 WEST WACKER DRIVE, CHICAGO 1, ILL.



Lead-Bearing Steel

Continued from page 144

No. 2 Automatic, the sequence of operations is: threading ½ in.—20 thread, cut-off, and slot. The following comparisons in machining time and speed were obtained:

B-1113	*Ledloy*
Surface Feet per Minute	
220	276
Time per Piece, Total Operation	
17½ sec	14 sec

Again, these figures, which indicate a 25.5% increase in surface ft per min and a 25% increase in production, do not take into account increased production per machine hour due to longer tool life. In addition, chaser life was doubled, a better finish secured, and overall quality of product was improved using Ledloy.

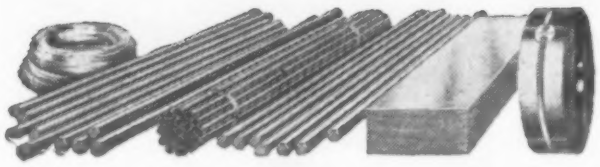
No attempt was made, in conducting these studies, to determine accurately the cost per piece of finished parts. In general, however, it may be said that, with the cost of Ledloy running about 13% higher than B-1113, increased production per machine-hour more than offset the additional material costs, effecting a worthwhile saving.

Jobbing screw machine operators are sometimes limited as to the steel they can use, depending upon customers' specifications. With faster cutting screw steel available, specifications can frequently be changed with a resulting lowering of cost of the finished product. It should be pointed out, however, that when a faster cutting steel is specified, shop operations must be adjusted—speeds and feeds of screw machines increased—so as to realize the full cost saving possibilities offered by the improved material.

Summarizing the results of the studies, Ledloy was found to have three distinct advantages: (1) allows stepped-up speeds and feeds in machining; (2) permits longer tool life; and (3) allows production of higher quality products with exceptionally fine machine finishes.

Free Technical Courses Given

Free technical courses in quality control and spring design and specification are being offered for the third year by Hunter Spring Co., Lansdale, Pa. An 8-page bulletin describing these two-day plant courses is available from the company.



BRIDGEPORT BRASS COMPANY

COPPER ALLOY BULLETIN

"Bridgeport" BRASS CO. MILLS IN BRIDGEPORT, CONN. AND INDIANAPOLIS, IND.—IN CANADA: NORANDA COPPER AND BRASS LIMITED, MONTREAL

Selling to Department of Defense —Army, Navy and Air Force

The information contained on this page relative to selling to the Military Departments of the Department of Defense was obtained from the Munitions Board Small Business Office.

Manufacturers, faced with material shortages and curtailment of civilian goods, are of necessity seeking defense orders to keep their plants operating. These do not come without effort on the part of the manufacturer.

However, a manufacturer may waste time seeking war orders through trips to Washington. Information, and eventually orders, can be obtained more quickly and easily by writing.

The Department of Defense, under which falls the Army, Navy and Air Force, has assigned to individual military departments responsibility to procure certain supplies and services for all three units.

At the same time the Army, Navy and Air Force have offices which buy for their individual needs.

Get on "Bidders Lists" for Prime Contract Work

All of these offices have what is known as "bidders lists". The manufacturer should be on these lists to receive a chance to bid on a formally advertised contract or to be approached for a negotiated contract.

Wherever possible, the advertised method is used. However, negotiated contracts are permitted under the recently declared national emergency.

The Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., has available three booklets. These publications list the purchasing offices of the Army, Navy and Air Force, and give a brief descriptive list of the items each purchases. The method of getting on "bidders lists" and the necessary steps in seeking contracts are also explained:

1. "How to Sell the U. S. Army" (30 cents).
2. "Purchasing Items and Purchasing Locations of the Department of the Navy" (20 cents).
3. "A Guide for Selling to the U. S. Air Force" (15 cents).

IT'S YOUR JOB!

There is no easy way to do business with the Government. You must exercise just as much initiative, enterprise and salesmanship as you would in doing business with private industry.

Another service is available to manufacturers for information as to the purchasing office to write to for a specific product or products. A letter listing products you are making or can make should be addressed to:

The Military Procurement
Information Office
Munitions Board
The Pentagon
Washington 25, D. C.

Information as to specific offices to contact for getting on bidders lists will be sent to you. This office will also answer questions pertaining to defense orders.

When you have obtained the name and address of the office, or offices, interested in procuring your goods, a simple letter, illustrated on this page, will either put your company's name on the bidders list or bring application blanks.

Daily Listing

As an aid to businessmen in obtaining current information as to what the Government is purchasing, and an opportunity to bid, the U.S. Department of Commerce publishes daily a "Consolidated Synopsis of U.S. Government Procurement Information." It lists the purchasing office making the procurement, the item contemplated and the amount, the invitation for bid number, and the bid opening date. A firm may bid on any item listed by writing to the office doing the buying, giving the IFB number, and requesting a bidding set.

Sub-contract Work

Up to this point only prime contracts have been discussed. There are, however, many concerns who can handle, or desire, only sub-contract work such as screw machine, press, tool shops, etc.

To facilitate small business in obtaining the names of the firms awarded unclassified Department of Defense contracts in amounts over $25,000, the Department of Commerce publishes weekly the "Consolidated Synopsis of Contract Award Information." This gives the name and address of the successful bidder, the commodity purchased, the quantity, and the value.

Both contract award and procurement information synopsis may be reviewed at your local Chamber of Commerce or nearest field office of the U. S. Department of Commerce. If you wish to receive these regularly write to:

U. S. Department of Commerce
Division of Printing Services
Washington 25, D. C.

Suggested Letter Seeking Bids

(Company Letterhead)

Commanding Officer
(Purchasing Office)
(City, State)

Dear Sir:

Our firm is desirous of supplying items centrally procured through your office, as outlined in pamphlet "How to Sell to the United States Army" and/or "Purchasing Items and Purchasing Locations of the Department of the Navy", and/or "A Guide for Selling to the U. S. Air Force".

Attached hereto is a list in duplicate of items which we desire to furnish. Where known, we have also indicated the applicable Government specification.

As we have never before bid on business through your office, we are attaching a copy of our most recent balance sheet, and profit and loss statement.

It is recognized that your office is extremely busy under the impact of procurement necessitated by the present emergency. No formal reply is requested, however, we would like the duplicate list returned to us in the enclosed self-addressed stamped envelope. Please mark any items that are not procured by your office, and if possible indicate the appropriate purchasing office.

Yours truly,

News Digest

German Aluminum Delivery

continued from page 8

required to meet the increasing demand for aluminum, which is being widely used as a substitute for even-more-scarce copper.

Meanwhile, aluminum production in Italy increased to between 33,000 and 34,000 tons in 1950—its highest post-war level—and Italian industry is thinking in terms of 38,000 tons for 1951. With stockpiles increasing and a falling internal consumption (only 12,000 tons in 1949), Italian aluminum producers are again asking their government to allow the resumption of aluminum exports, which are forbidden at present.

All-Aluminum Bridge Built

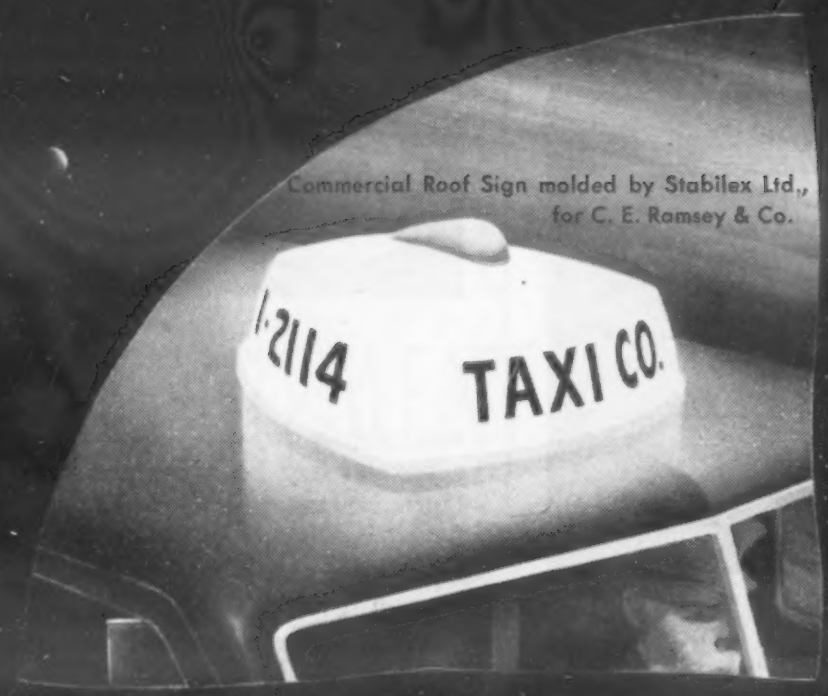
Last year saw the completion of the world's first all-aluminum highway arch bridge. The 290-ft span crosses the Saguenay River at Arrida, Quebec.

High-strength copper-bearing alloys were used in the construction. Because of lack of high-temperature strength in these structural aluminum alloys, flame cutting and welding could not be used. However, the material was easily sawed and its light weight facilitated handling considerably.

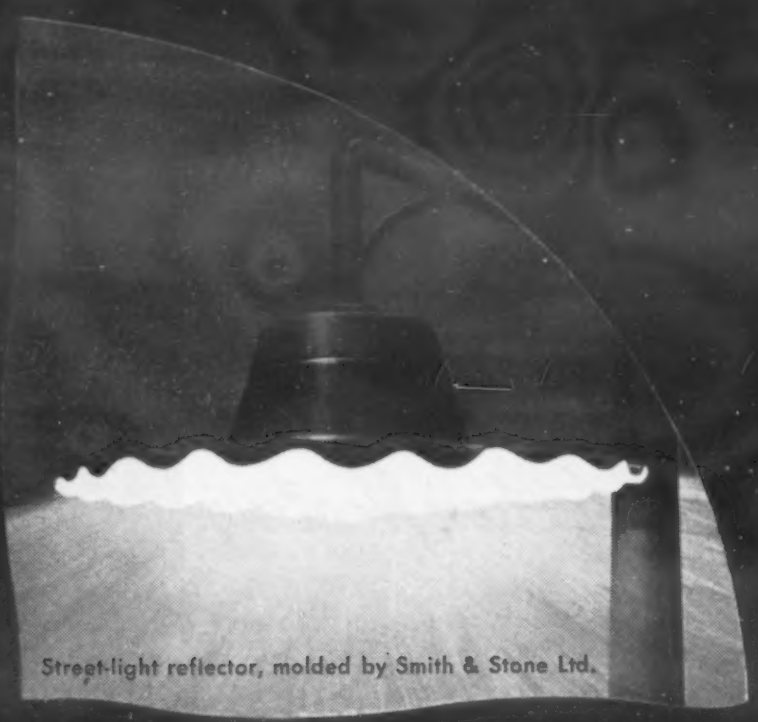
New Process Developed for Bonding Rubber to Metal

A new method of bonding rubber to metal which should revolutionize this important process is revealed in the current issue of *Rubber Developments,* the quarterly prepared by the British Rubber Development Board.

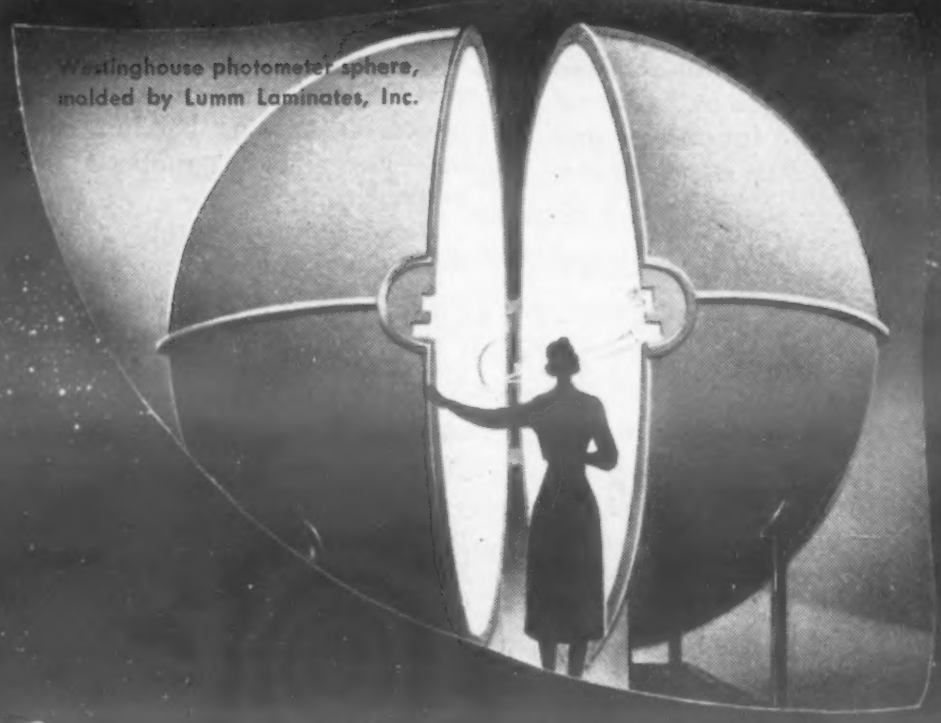
Until this new procedure, called the Redux process, was devised, an essential prelude to bonding rubber to metal was the surfacing of the metal with brass. Because of the various control factors and expense involved, the use of such bonding



Commercial Roof Sign molded by Stabilex Ltd., for C. E. Ramsey & Co.



Street-light reflector, molded by Smith & Stone Ltd.



Westinghouse photometer sphere, molded by Lumm Laminates, Inc.

All ways light and always right...

Products made with LAMINAC® Laminating Resins

Here's what LAMINAC Resins can put into products by way of special performance features:

STRENGTH AND LIGHT... Commercial signs made with LAMINAC Resins are so translucent that *one* electric bulb illuminates them brilliantly. Because of LAMINAC's superior strength, the seller fully guarantees them against breakage under normal use.

LIGHTNESS AND STRENGTH... Five times lighter than one made of iron, and 35,000 times as large as a baseball, the new Westinghouse photometer meets all requirements for strength, ease of handling and maintaining, ease and economy of production.

STAMINA AND LIGHTING... Street lamp reflectors shed light on the toughness and durability of LAMINAC Resins. They offer all kinds of resistance to all kinds of weather, corrosion, and small-boy mischief.

AMERICAN *Cyanamid* COMPANY

PLASTICS DEPARTMENT

34-M ROCKEFELLER PLAZA, NEW YORK 2, N. Y.

In Canada: NORTH AMERICAN CYANAMID LIMITED, *Royal Bank Building, Toronto, Ontario, Canada*

News Digest

was greatly limited. Although some adhesives had been developed in the United States and Germany that effected a bond without the brass finish, these also involved expensive procedures that limited their use.

In the new process, the rubber surface is treated with concentrated sulfuric acid for 4 min, and then thoroughly washed in running water and dried. This results in the surface being "Cyclized"—hardened a little and covered with fine cracks or crazing noticeable only on bending the rubber—and gives the rubber better adhesive properties.

Next, both the rubber and the thoroughly cleaned metal surfaces are painted with thin coats of Redux liquid resin and dipped in Redux powder. The rubber and metal are then clamped together under a pressure of 50 psi and baked at 284 F for 20 min.

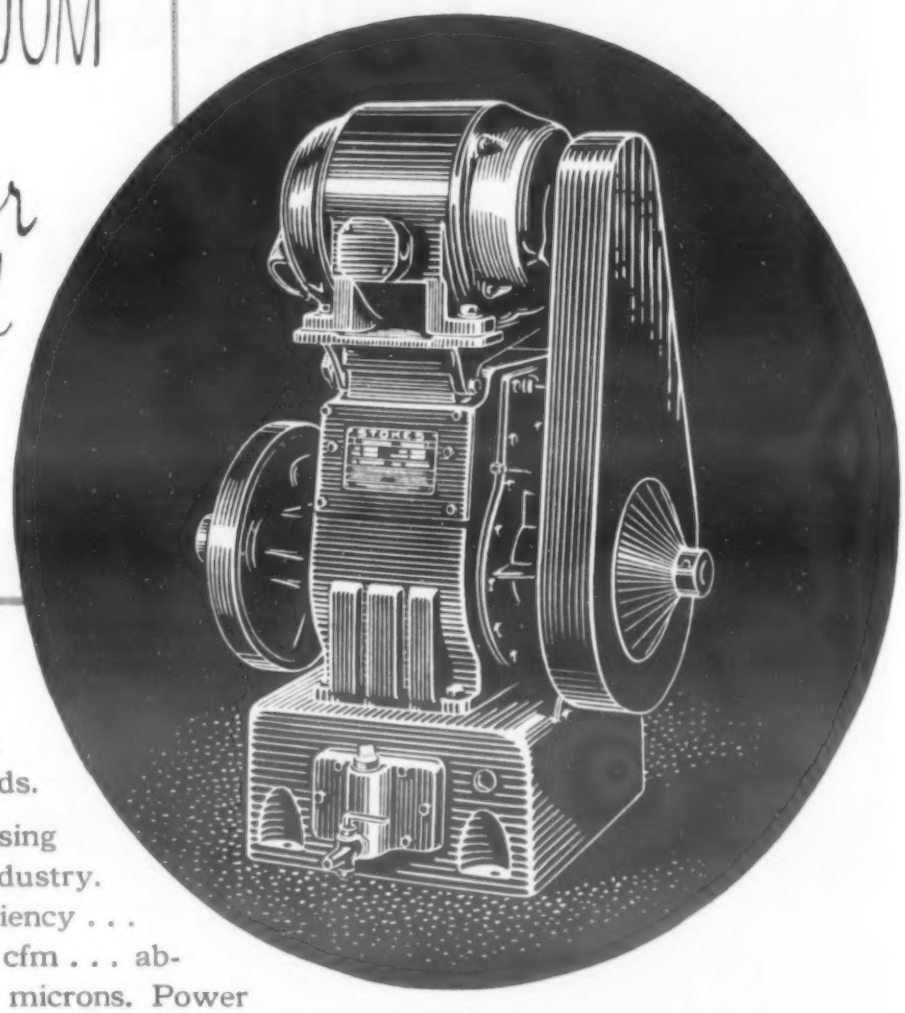
Although this process is designed primarily for hard rubbers, a variation of the procedure makes it applicable to softer types also. In addition, rubber can be bonded to Bakelite, Tufnol, Delaron and similar materials with equal satisfaction.

Sulfuric Acid Corrosion Tests Made on Nickel-Chromium Stainless Steels

Corrosion tests which were carried out by the simple immersion in sulfuric acid of specimens of 17:10 chromium-nickel steel containing 2.5% molybdenum are reported in a recent issue of *Revue de Metallurgie*. To duplicate industrial conditions, normal impurities found in industrial acid were added in known quantities. Potential vs. time measurements demonstrated that the presence of sulfate and thiosulfate ions, and of organic nitrogen and sulfur compounds, had an adverse effect on corrosion resistance of the steel. Ferrous, lead, chlorine and ammonium ions had no effect, while ferric, arsenious, nitric and nitrous ions actually inhibited the corrosive action of the acid.

The effect of adding nitric acid, shown by preliminary tests to be

STOKES HIGH VACUUM EQUIPMENT... for every requirement of vacuum processing



Modern design of Stokes vacuum equipment develops from the continuing contact of Stokes Engineers with processors in many fields.

Stokes Microvac Pumps — basic to vacuum processing —are designed for the broadest requirements of industry. They have high volumetric and mechanical efficiency . . . capacities of 15 to 500 cfm . . . absolute pressures to 10 microns. Power consumption is low. Compact design with top-mounted motor requires minimum floor space.

There are but four moving parts including the high speed, full-opening exhaust valve of corrosion-resistant Teflon. Lubrication is completely automatic, without packing, stuffing-boxes or grease fittings. Wear is kept to a minimum, and long trouble-free service assured. Parts are precision-finished, standard and interchangeable.

Stokes is the only manufacturer of equipment for complete vacuum systems, including Microvac mechanical pumps, oil diffusion pumps, McLeod Gages and Vacuum Valves.

Consult with Stokes on the application of vacuum to vacuum sintering, melting, de-gassing, heat treating, inert gas purging, vacuum metallizing, and to other applications in which vacuum deserves exploration.

Send for Catalog 700, "Stokes Microvac Pumps for High Vacuum", now a standard reference work on High Vacuum, containing charts, graphs, diagrams, schematics, typical problems, tables, formulas, constants, conversion factors.

STOKES

STOKES MAKES

Plastics Molding Presses,
Industrial Tabletting
and Powder Metal Presses,
Pharmaceutical Equipment,
Vacuum Processing Equipment,
High Vacuum Pumps and Gages,
Special Machinery

F. J. STOKES MACHINE COMPANY, 5972 TABOR ROAD, PHILADELPHIA 20, PA.

News Digest

advantageous, was studied in greater detail. Tests with solutions containing up to 2% nitric acid indicated that rapid corrosion with free liberation of gas was suppressed. Similar results were obtained with the addition of sodium nitrite.

It is concluded that the behavior of 18:8 molybdenum steel in sulfuric acid is largely determined by the impurities in the acid, which, in some cases, may have as great an influence on corrosive action as the surface condition of the material exposed. Optimum resistance to the acid was obtained by adding to it a small amount of oxidizing compound.

Hardness of Stainless Steels Tripled

Westinghouse Electric Corp. has revealed the discovery of a process that can triple the hardness of stainless steels. The new procedure calls for a unique low temperature treatment in which the steel is immersed in liquid nitrogen baths at −300 F and rolled or forged at sub-zero temperatures. Heating at controlled temperatures then further increases the hardness. Hardened stainless steel produced by this process is expected to have wide use as a wear resistant material in bearings, valve seats, springs, and other machine parts.

Wraps Off British Nickel Alloy

A new nickel-base, high-temperature alloy known as Nimonic 90 has been announced by Mond Nickel Co., Ltd., in England.

The alloy is a modification of the Nimonic series and makes use of cobalt as a major alloying element. Its properties are quite similar to those of Inconel X, developed in this country by The International Nickel Co., Inc. (see MATERIALS & METHODS, October 1949, pp. 57-61).

Although the wraps were taken off the new material just recently, it has been used for some time in several gas turbine engines.

MANUFACTURER CUTS TOOLING COST $800.00

BY simple redesign to welded steel, substantial savings are being effected in the production of these bearing housings. At the same time, product strength and rigidity have been increased to assure maximum serviceability . . . long-lived operation. An initial saving of $800.00 on setup and tooling expense results from the elimination of drill jigs and boring fixtures as well as for patterns and core boxes required with the original construction.

Component parts are now preformed prior to welded assembly in a plain, low-cost, clamp type fixture. The tubing itself is bored as a simple lathe operation and the legs prepunched and bent as shown.

The resulting simplified production now possible with the welded steel construction is increasing the rate of output . . . reducing unit cost $1.12 per piece.

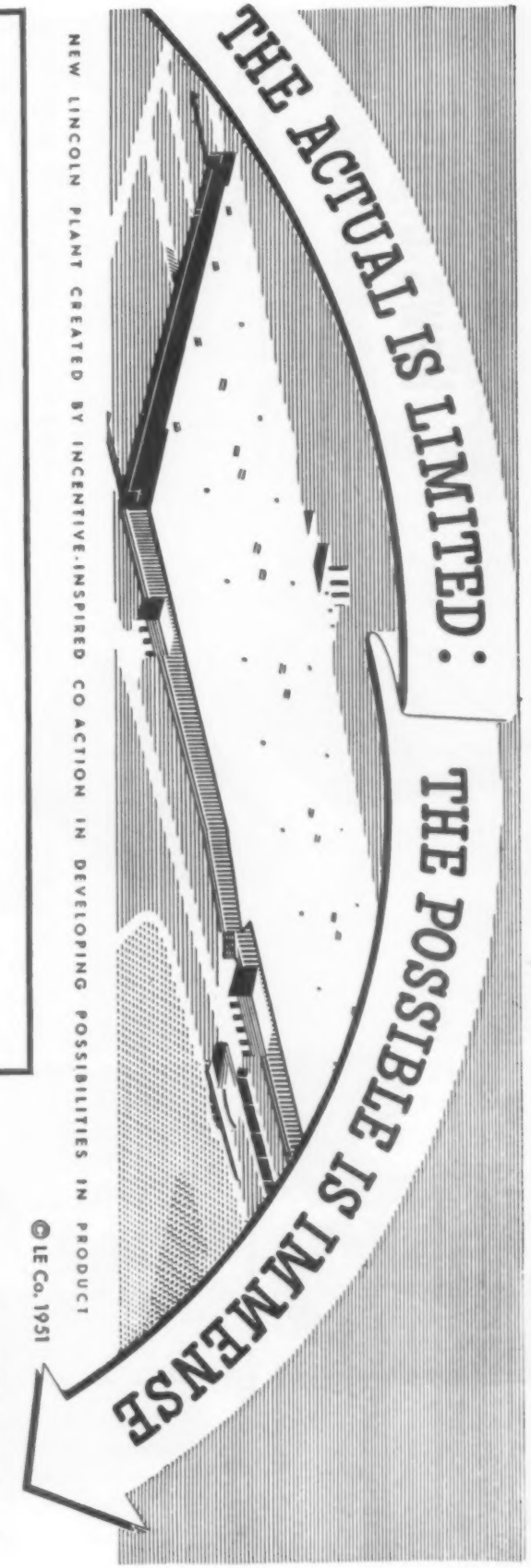
Present Design *of bearing housing at Oliver Corporation, Springfield, Ohio, has 3" heavy wall pipe and plain formed legs. Requires but single pass weld. Costs $1.12 less than original construction.*

How To DESIGN FOR WELDED STEEL is presented in the new 9th Edition "Procedure Handbook of Arc Welding Design and Practice." Contains latest data on machine design together with cost figures. Price only $2.00 postpaid in U.S.A.; $2.50 elsewhere.

Machine Design Sheets free on request to designers and engineers. Write on your letterhead to Dept. 411,

THE LINCOLN ELECTRIC COMPANY

CLEVELAND 1, OHIO



NEW LINCOLN PLANT CREATED BY INCENTIVE-INSPIRED CO ACTION IN DEVELOPING POSSIBILITIES IN PRODUCT

© LE Co. 1951

the ACTUAL

Original Cast Construction *of bearing housing required fixtures for extensive boring and drilling operations.*

increasing the YIELD

First Changeover *to welded steel design has 90° formed legs welded to thin wall tubing. Was welded top and bottom as shown.*

the IMMENSITY of the POSSIBLE

A saving in cost of 24%

SEE HOW WELDED STEEL DESIGN SIMPLIFIES PRODUCTION

News Digest

Cobalt Sources

continued from page 11

Bethlehem Steel Co. produced 673,-773 lb of cobalt in 1949. Recently, however, the development of a new process to recover cobalt from complex concentrates containing arsenic or lead has made it possible to exploit three new sources of cobalt—ore bodies near Salmon, Idaho, Fredericktown, Mo., and Cobalt, Ont.

By 1953, when these new sources are fully developed, it is expected that a total of 12,650,000 lb of cobalt will be available annually to the U. S. from the following areas:

Source	*Cobalt, Lb*
Belgian Congo	7,500,000
French Morocco	900,000
Idaho	3,000,000
Missouri	500,000
Cobalt, Ont.	750,000
Total Lb Annually	12,650,000

Although the NPA ordered a 70% cut in cobalt consumption for non-essential industries last November and is expected to issue an order this month allocating all available supplies of cobalt for defense production, the outlook for consumer goods industries should begin to brighten as the new cobalt sources are developed. Furthermore, if the production of cobalt planned for 1953 is achieved, there will probably be adequate supplies for both normal consumer demand and military requirements.

Electron Microstructure Report

A 50-page report on "Electron Microstructure of Steel" has been published by the American Society for Testing Materials.

Presented at the ASTM annual meeting last June, this is the first progress report of Subcommittee XI on Electron Microstructure of Steel which functions as a part of Committee E-4 on Metallography. The report includes 47 specially prepared illustrations showing electron micrographs of various steels.

Copies of the pamphlet may be

What's good grooming for a golf shaft?

...a brush!

Prior to plating, golf shafts must be perfectly clean, free of heat-treat discoloration and surface imperfections. In cleaning and finishing, the problem was to get into the corners of the tapered True Temper "step-down" and to do the job in one pass at high speed.

The problem was solved with a five-station, in-line automatic machine equipped with Osborn Fascut® Brushes. This automatic brushing gives the shafts a smooth, uniform finish over the entire surface . . . and it has increased output 20% over the former method.

Perhaps new Osborn brushes and brushing techniques can improve *your* products and step up your productivity. An **O**sborn **B**rushing **A**nalyst will gladly survey your operations. Write today for an **OBA!** *The Osborn Manufacturing Company, Dept. 391, 5401 Hamilton Ave., Cleveland 14, Ohio.*

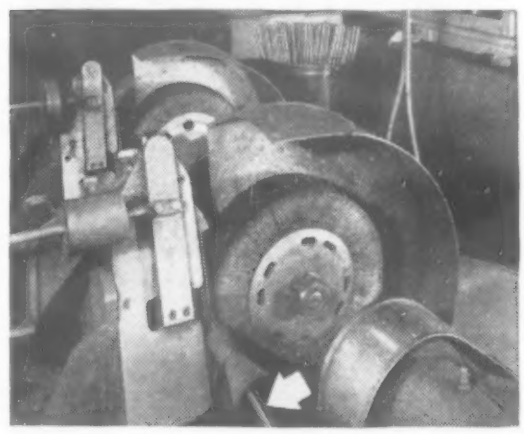
OSBORN

LOOK FOR THE NAME OSBORN . . . RECOGNIZED EVERYWHERE FOR QUALITY WORKMANSHIP AND MATERIALS

Osborn Brushes step up finishing output 20%

The problem here was to remove heat-treat discoloration and surface imperfections from golf shafts prior to plating. Due to the tapered True Temper "step-down" design of the shaft, it was difficult to get into the "step-down" corners with the former method. Two or three passes were required for thorough cleaning.

Now, with the five-station machine shown above, Osborn Fascut® Brushes, with compound, finish the shafts in one pass, netting a 20% increase in output. Uniform quality of finish over the entire surface is duplicated accurately from piece to piece due to the ability of the Fascut Brushes to blend with the exact contour of the golf shaft.



Brushes run at 900 rpm. Output of the machine is 1500 shafts per 8 hours or about 10 feet of shaft per minute.

If your production problem involves finishing or cleaning of parts, an **O**sborn **B**rushing **A**nalysis most likely will demonstrate how this work can be done more efficiently . . . at less cost with new, improved power brushing techniques. Call or write Osborn for this service. There is no obligation.

News Digest

obtained from the ASTM, 1916 Race St., Philadelphia 3, at $1.35 each.

Rubber Production Reaches All-Time High

All-time production and raw material records were achieved by the rubber manufacturing industry in 1950 "despite the most difficult supply and cost problems," according to Rubber Manufacturers Association, Inc. With all branches of industry reporting a higher level of activity, a total of 1,240,000 long tons was consumed in 1950—25% more than in 1949. This included 711,000 long tons of natural and 529,000 long tons of synthetic rubber.

News of Engineers

Walter Kennedy has been appointed chief engineer of the Technical Div. of the United States Plywood Corp. He will make his headquarters in Palmer, Mass.

Westinghouse Electric Corp. has promoted *A. M. Harrison* from the position of manager of the D.C. Machine Section to manager of the D.C. Engineering Dept. of the Transportation and Generator Div. He succeeds *Clarence Lynn,* who has recently undertaken important engineering responsibilities at the Company's Atomic Power Div.

John W. Pennington, formerly staff engineer for the Caterpillar Tractor Co., has joined Koppers Co., Inc. as chief engineer of its Piston Ring Dept.

Lenkurt Electric Co. has named *Kurt Appert,* vice president and chief engineer, to the position of director of engineering. Simultaneously, it was announced that *George M. Lebedeff* joined Lenkurt as chief engineer. Mr. Lebedeff previously served as chief engineer of Heintz and Kaufman and as an engineer with Federal Telegraph Co.

Walter K. Grant has joined Continental Foundry & Machine Co. as chief electrical engineer of its Rolling Mill & Special Equipment Div. Mr. Grant formerly was connected with United Engineering and Foundry Co.

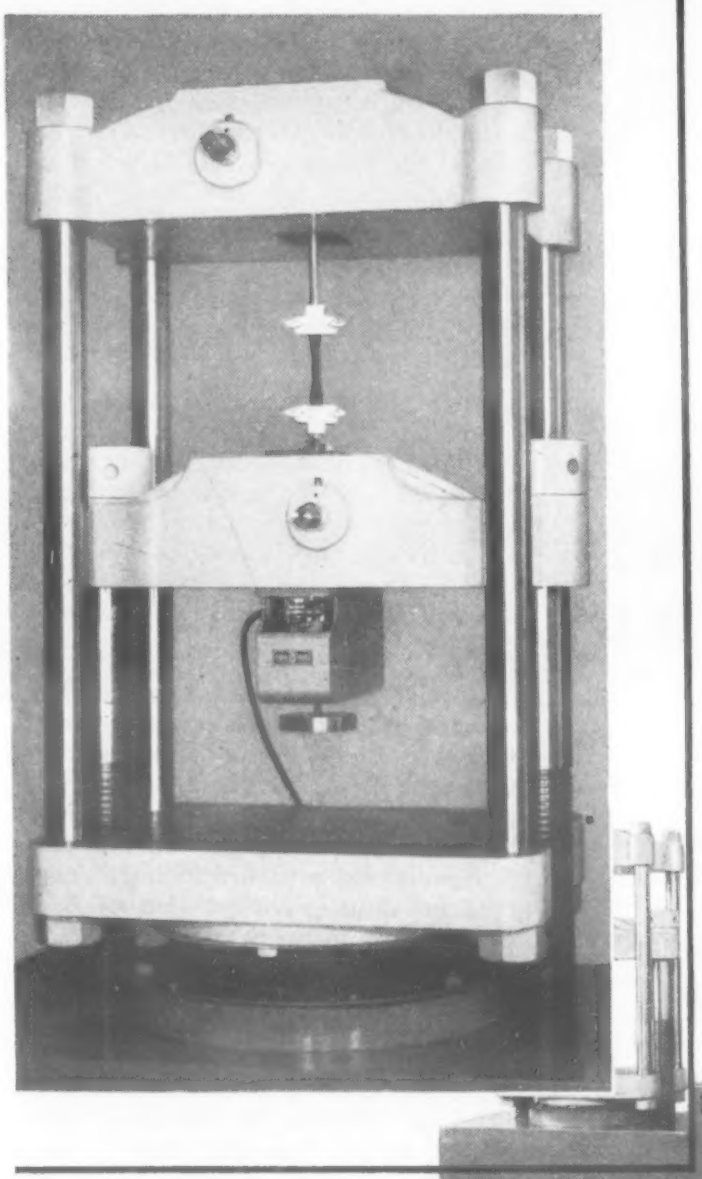
J. S. Johnson has been appointed as-

new

OLSEN ELECTRONIC LOAD CELL

provides

1000 to 1 extra low range



New Olsen 200,000 lb. Super "L" with SelectoRange indicating system. Electronic load cell illustrated above.

Just attach it to the crosshead of the new Olsen Super "L" with SelectoRange indicating system, and plug it in—and you have the use of a highly accurate "super low" (1000 to 1) testing range. You can read by ¼ lb. marks on a 200,000 lb. machine when using a 200 lb. cell which is connected directly to the dial indicator.

This completely new load cell which employs an "atcotran" differential transformer, is a compact unit built into an auxiliary weighing system. Available in a range of capacities, the Olsen Electronic Load Cell may be used for compression or tension testing, and with or without an electronic recorder. Construction is simple, installation is a matter of but a minute or so, operation is elemental, and there is nothing to get out of order.

The Electronic Load Cell is another reason why the Olsen Super "L" is today's "way out in front" best buy in Universal testing machines.

Write today for information about both the Super "L" and the Electronic Load Cell.

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Testing & Balancing Machines

TINIUS OLSEN
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2010 Easton Rd., Willow Grove, Pa.

News Digest

sistant to the president of United States Rubber Co. He succeeds *G. R. McNear,* who was elected a director and managing director of the North British Rubber Co., Ltd., in which U. S. Rubber is a substantial stockholder.

The election of *Edward J. Hanley* as president of Allegheny Ludlum Steel Corp. has been announced. Mr. Hanley succeeds *E. B. Cleborne,* who resigned as president but will continue to serve the company as a director and vice president. *Clark W. King,* vice president and treasurer, assumes Mr. Hanley's position as executive vice president, and will retain his position of treasurer. At the same time, *Frank B. Lounsberry* resigned as vice president and technical director, and *W. B. Pierce,* manager of the company's Sales Development & Engineering Service Dept., became technical director

George L. Bachner, president of the Powdered Metal Products Corp. of America, was appointed industrial consultant to the Chief of Ordnance, U. S. Army.

The election of Captain *David R. Hull,* U.S.N. (Ret.) as a vice president of Raytheon Manufacturing Co. has been announced. At the same time, Captain Hull became manager of the Equipment Divs., succeeding *Wallace L. Gifford,* who is continuing with the company as a director and vice president in an advisory capacity.

General Electric Co. has announced a number of changes of personnel in its various divisions. In the Large Motor and Generator Divs., *Arthur H. Lauder,* assistant manager, was named manager of engineering. He succeeds the late *Earle S. Henningsen,* who died recently. *Joseph F. Eckel* assumes the position of *J. M. Crawford* as manager of the Divs. Mr. Crawford was transferred to Pittsfield, Mass., as manager of the Transformer and Allied Product Divs. *Herbert L. Ross,* formerly manager of manufacturing of the Meter and Instrument Divs., succeeds Mr. Eckel as manager of the Lynn River Works. In the Chemical Dept., *Austen W. Boyd,* chemical engineer for GE, was placed in charge of the Chemical Process Development group at Waterford, N. Y. And finally, *William E. Ruder* was appointed manager, and Dr. *John H. Holloman* assistant manager, of the newly organized Metallurgy and Ceramics Divs. of GE's Research Laboratory. Under the reorganization, the former Metallurgy Div. has been divided into four divisions: the Chemical Metallurgy and Structures Div., headed by Dr. *David Turnbull;* the Physical Metallurgy and Cryogenics Div., under Dr. *John C. Fisher;* the Materials and Process Div., of which *James D. Nisbet* is head; and the Ceramics Div., continued to be headed by Dr. *Louis Navias.*

TIGHTENING the belt on production costs? Then be sure that you don't have too much of your good steel stock lying on the floor as scrap. It's wasteful, expensive and usually unnecessary.

You can save money, time and steel when you use SHELBY Seamless Steel Tubing for hollow cylindrical parts. With tubing, less cutting or boring is required than with solid bars . . . tools last longer. And, since *the basic shape is already made,* fewer operations are required. Rejects go down. Time is saved.

For some good examples of how other parts manufacturers have simplified their production cost problems, take a careful look at the products on this page. Despite the complexity of some, each of them was made from SHELBY Seamless Steel Tubing. In some cases, manufacturing costs are *50%* less than identical products machined from solid bar stock.

Our service engineers will be glad to help you utilize the many advantages of seamless steel tubing for *your* product. Get in touch with us today, draw upon the priceless experience of National Tube Company—world's largest manufacturer of tubular steel products.

FREE BOOKLET

Tells you how to cut production time, production costs, and make better parts in the bargain. Write to National Tube Company, Frick Building, Pittsburgh 19, Pennsylvania.

NATIONAL TUBE COMPANY, PITTSBURGH, PA

(TUBING SPECIALTIES DIVISION)

COLUMBIA STEEL COMPANY, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS

UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS TRADE MARK

Shelby Seamless Steel Tubing

UNITED STATES STEEL

News Digest

Robert G. McAllen has been appointed to the position of assistant to the president of Horizons Inc. He will make his headquarters in Princeton, N. J. It was also announced that Dr. *J. L. Snoek* was named head of the Physics Dept. of Horizons.

The following changes in executive positions of the Doehler-Jarvis Corp. have been announced: *Charles Pack,* vice president in charge of production, was named vice president in charge of the newly formed Engineering and Research Dept.; *W. G. Gutmueller,* vice president and secretary, is now vice president and production manager; *Louis Miller,* director of public relations, becomes assistant vice president; *Harold L. Samuels,* assistant secretary, was named secretary; and *H. C. Manderville* was appointed assistant secretary.

E. J. Rathsack has joined Kenworth Metal Stamping Co. as secretary and engineer-in-charge of production. Prior to this new assignment, he had served as engineer-in-charge of the Electronic Induction Heating Dept. of the Allis-Chalmers Manufacturing Co.

E. I. du Pont de Nemours & Co. (Inc.) has made the following changes within its organization: *Donald O. Notman,* assistant general manager, was named general manager of the Electrochemicals Dept. *Charles B. McCoy,* director of sales of the Explosives Dept., succeeds Mr. Notman as assistant general manager of the Electrochemicals Dept. *J. Sharp Queener,* general assistant manager, assumes the position of manager of the Safety and Fire Protection Div., vacated by the retirement of *Harold L. Miner.* After 14 years in the Acetate Div. of du Pont's Rayon Dept., Dr. *Bruce S. Farquhar* was named assistant manager of the acetate fabric development section. He will be located in New York City. And finally, *Samuel G. Baker,* formerly general manager of the Electrochemicals Dept., replaces *James S. Denham* as general manager of the Photo Products Dept. Mr. Denham has retired after serving 35 years with du Pont.

Dr. *Woodford Sink* has joined Fisher Scientific Co. as director of technical training. His headquarters will be at the main office in Pittsburgh, Pa. Another new member of the firm is *J. William Geisler,* who will serve as petroleum apparatus engineer. Mr. Geisler formerly was associated with the Bureau of Mines.

The retirement of *George R. Siegrist* as executive vice president, treasurer and director of the Acheson Colloids Corp. has been announced. Mr. Siegrist has been associated with Acheson for 30 years.

Bjorksten Research Laboratories, Inc. has announced the following additions to

(*Continued on page 166*)

MANUFACTURERS' LITERATURE

Materials

Irons • Steels

Tool Steel Selector. Crucible Steel Co. of America. Selects tool steel for desired application. Indicates type steel, hardening depth and heat treating information. (4)

Machinable Steels. Jones & Laughlin Steel Corp. Properties and grades of J & L "E" Steel, said to have high machinability, give better finishes, and extend tool life. (5)

Alloy Steel. Joseph T. Ryerson & Son, Inc., 2 pp. Describes Ledloy, leadbearing open hearth steel said to machine 30 to 50% faster than fastest previously available screw steel. (8)

Low Alloy and Stainless Steels. Sharon Steel Corp., 4 pp, ill, No. 1a-26. Details of company's stainless, high tensile, low alloy steels, Cor-Ten and N-A-X. (9)

Nonferrous Metals

Corrosion Resistant Alloys. Ampco Metal, Inc., 4 pp, ill. Physical properties, fabricating qualities and corrosion resistance of Ampco Metal grades. Shows numerous applications. (11)

Low Temperature Melting Alloys. Cerro de Pasco Copper Corp. Technical data and applications of Cerro low temperature melting alloys useful in many phases of industry. (12)

Magnesium. Dow Chemical Co., 8pp, ill, *Magnesium Topics*, Vol. 1, No. 4. Articles on extrusion of powdered magnesium alloys and sand casting magnesium. (13)

Spring Alloys. Elgin National Watch Co., Industrial Products Div., 2 pp. Composition, properties and applications of Elgiloy, cobalt-chromium-base spring alloy. (14)

High Temperature Alloys. Haynes Stellite Div. *Haynes Alloys for High Temperature Service* provides detailed tables and charts on their properties and heat treatment. (15)

High Temperature Alloy. The International Nickel Co., Inc. *Keep Operating Costs Down When Temperatures Go Up* shows applications of Inconel to high temperature service. (16)

Bronze and Babbit Metal. National Bearing Div., 1 p. Prices of "Tiger Bronze" cored and solid bars and babbitt metals for bearings. (17)

Precious Metals. The J. M. Ney Co., 19 pp, ill, No. R-12. Properties, recommended uses and specifications of available types of precious metal alloys for sliding electrical contacts. (18)

Nonmetallic Materials • Parts

Plastic Moldings. Accurate Molding Co. Describes facilities for producing precision plastic moldings. Case histories given. (19)

Molded Soft Rubber. Acushnet Process Co., 32 pp, ill, No. 50. Describes facilities for making wide range of precision molded soft rubber parts to order. (20)

Felt Seals. American Felt Co. Data Sheet No. 11 gives detailed design factors and applications of felt seals. (21)

Plastics. American Hard Rubber Co. *Ace Handbook* supplies data on hard rubber and plastics useful to the designer of nonmetallic parts. (22)

Extrusion and Molding Materials. Bakelite Div., 22 pp, ill, No. J-675. Detailed average properties, uses and suggestions for design of Vinylite extrusion and molding compounds. (23)

Molding Compounds, Resins and Cements. The Borden Co., Chemical Div., 8 pp, ill, No. 10M. General properties and uses of Durite specially prepared phenolic molding compounds, resins and cements. (25)

Plywood. Douglas Fir Plywood Assn. *1000 Uses of Douglas Fir Plywood* suggests numerous ideas for the application of plywood to many industries. (26)

Insulating Material. Dow Corning Corp., No. 10. *Silastic Facts* gives properties, performance and applications of Silastic, silicone insulator said to have good thermal stability. (27)

Flexible Tubing. Flexible Tubing Corp., 8 pp, ill, No. 5-4. Applications and performance data on Spiratube flexible tubing for ventilation and materials conveying. (28)

Laminated Plastic Parts. The Formica Co. Catalog gives full information on company's facilities for complete machining of Formica custom made parts. (29)

Plastics Surfacing. General Electric Co., Chemical Dept., 16 pp, ill, No. CDL-18. Describes Textolite, plastic surfacing for counters and tables said to be colorful and resist abuse. (30)

Polyvinyl Plastics. B. F. Goodrich Chemical Co., 16 pp, ill. Properties and descriptions of Geon resins for such applications as extrusions, wire and cable, flooring and molded parts. (31)

Rubber Reinforcing Resin. Goodyear Tire & Rubber Co., Chemical Div., No. 601-B. Features and applications of Pliolite S-6B resin affording greater plasticity in rubber processing at low temperatures. (32)

Self-Lubricating Bushings. Graphite Metallizing Corp., 8 pp, ill. Properties and advantages of graphalloy grades for bushings and electrical uses. Includes bearing design data. (33)

Perforated Materials. The Harrington & King Perforating Co., No. 62. Catalog gives data on fabrication methods, how to order, types of perforation, and uses of perforated materials. (34)

Synthetic Resins. Hercules Powder Co., Synthetics Dept., 20 pp, No. 967. Brief description of properties and applications of Hercules resins, enabling intelligent choice by prospective users. (35)

Metal Hydrides. Metal Hydrides, Inc., 4 pp. Explains use of metallurgical and chemical hydrides for such applications as alloying, producing hydrogen and reduction of chemical compounds. (36)

Carbon Products. Morganite, Inc., 8 pp, ill, No. 1f. Specifications of various carbon bearings and bushings. Also properties of six series of Morganite carbon products. (38)

Nonmetallic Pipe. National Carbon Div., 16 pp, ill, No. CP-2212. Chemical resistance, properties and specifications of pipe and fittings of Karbate, phenolic impregnated carbon and graphite. (39)

Impact Phenolics. The Rogers Corp. Booklet shows various types of Fiberloys, including molding compounds in sheet and bulk form, laminated plastics and paperboards. (40)

Cast Acrylic Sheet. Rohm & Haas Co., Plastics Dept., 5 pp, No. 68. Properties, fabrication and forming information, and applications of Plexiglas II, heat resistant plastic adapted to weathering. (41)

Cellular Rubber. Rubatex Div., Great American Industries, Inc., No. RBS-12-49. Features of Rubatex closed cell rubber for cushioning, gasketing and shock-absorbing. (42)

Synthetic Rubber. Rubber Chemical Div., E. I. du Pont de Nemours & Co., Inc., 12 pp, ill, No. 43. Uses of Neoprene in parts necessitating high chemical resistance. (43)

Electrical Contacts. Stackpole Carbon Co., No. 12. Data on electrical contacts and their uses, including electrical brushes, electrodes and plates, and carbon regulator disks. (44)

Rubber Parts. Stalwart Rubber Co., 16 pp, ill, No. 51SR-1. Describes applications and fabrication of rubber compounds designed to resist temperature, abrasion,

To obtain literature appearing on these pages, please refer to easy-to-use reply card on page 163

MANUFACTURERS' LITERATURE

chemicals and weathering. (45)

Ceramics. Stupakoff Ceramic & Mfg. Co., 4 pp, No. 849. Properties of Stupalith, new ceramic said to be unsurpassed in thermal shock resistance. (46)

Carbon-Graphite Parts. U. S. Graphite Co., 68 pp, ill, No. G-49. Properties, chemical resistance, limitations, assembly information, design aids and 60 applications of Graphitar. (47)

Polyvinyl Resins. U. S. Rubber Co., Naugatuck Chemical Div., 20 pp, ill. Properties, ingredients, compounding and processing of Marvinol polyvinyl chloride resins. (48)

Plastics Parts. Watertown Mfg. Co., 44 pp, ill. Complete data on properties and applications of plastics produced by this company. (49)

Felt. Western Felt Works, 32 pp, ill. History of manufacture and uses of felt, including brief description of present-day methods and applications. (50)

Metal Parts • Forms

Precision Investment Castings. The Adapti Co., 4 pp, ill. Close tolerances and stronger metals are among advantages listed for Adapti Method of precision casting. (52)

Precision Castings. Alloy Precision Casting Co., 8 pp, ill. Describes frozen mercury process for close tolerance precision casting of parts made to order. (53)

Aluminum Extruded Shapes. Aluminum Co. of America, No. AD-229. Explains potentialities of extrusion process for aluminum to save money in fabrication operations. (54)

Aluminum Parts. Aluminum Goods Mfg. Co., 56 pp, ill. Catalog covers extensive production facilities and technical services for producing wide range of parts. (55)

Prefinished Metals. American Nickeloid Co,. 4 pp. Sampler shows finishes and platings available on zinc, steel, copper, brass and aluminum-base metals with actual sample. (56)

Continuous-Cast Copper Alloys. American Smelting and Refining Co., 12 pp. Technical data on company's continuous-cast copper alloy rods, tubes and shapes. (57)

Stainless Steel Parts. Amplex Mfg. Co., 1 p, ill. Information on bearings, finished machine parts and permanent filters made from Oilite stainless steel. (58)

Small Parts. The Bead Chain Mfg. Co. Data bulletin describes company's Multi-Swage Process for economical manufacture of small parts up to ¼-in. dia and 2-in. lengths. (59)

Magnesium Parts. Brooks and Perkins, Inc. Characteristics of, and design data on magnesium alloys. Shows examples of made-to-order parts produced. (60)

Die Castings. Doehler-Jarvis Corp., 4 pp, ill. Description of use of this company's die castings in automatic automobile transmission indicates complexity of parts company can make. (61)

Metal and Plastics Parts. The Electric Autolite Co., Bay Mfg. Div., 16 pp, ill. Shows wide variety of custom made ornamental and functional metal and plastics parts. (62)

Steel Tubes. Globe Steel Tubes Co., 8 pp, ill, No. 1a/12. Specifications and tolerances of Gloweld-welded seamless tube and pipe of Globe-iron and steel. (63)

Perforated Metals. Hendrick Mfg. Co., 4 pp, ill. Examples of perforated metal applications and various available perforation types. (64)

Helical Compression Springs. Instrument Specialties Co., Inc., 2 pp, ill. How to obtain economical assortment of 100 beryllium copper compression springs for development work. (65)

Precision Cast Parts. The Jelrus Co., Inc. Advantages of centrifugal precision casting for custom manufacture of complex parts accurately and rapidly. (66)

Bearings. Johnson Bronze Co. Series of data sheets give detailed technical information on bearing design, applications, types and maintenance. (67)

Aluminum Extruded Shapes. Light Metals Corp., 6 pp, ill. Shows facilities for producing a variety of aluminum fabrications and extruded shapes to order. (70)

Die Castings. Madison-Kipp Corp., 32 pp, ill. Describes company's aluminum and zinc die castings. Also shows Kipp Featherweight air grinder and Fresh Oil lubricators. (71)

Iron Castings. Meehanite Metal Corp., 4 pp, ill, No. 32. Detailed tabular summary of physical properties of Meehanite high quality gray iron castings. (72)

Investment Castings. Microcast Div., Austenal Laboratories, Inc., 2 pp, ill. Shows typical parts made of high-temperature difficult-to-machine alloys. (73)

Forged Brass Parts. Mueller Brass Co., 5 pp, ill. Lower cost, better machinability are among advantages stated for forgings over sand castings used for hardware. (74)

Seamless Tubing. National Tube Co. Explains time- and cost-cutting fabricating applications of this company's Shelby seamless steel tubing. (75)

Nonferrous Die Castings. The New Jersey Zinc Co., 28 pp, ill. Applications and principal features of Zamak-3 and Zamak-5 zinc alloy die castings. (76)

Steel Tubing. Ohio Seamless Tube Co. Informative booklet describes many methods of fabricating and forging steel tubing. (77)

Spun Shapes. Phoenix Products Co., Metal Spinning Div., 4 pp, ill. Describes Phoenixspun method for spinning spherical and extra deep-drawn contours. (78)

Aluminum Parts. Reynolds Metals Co., Industrial Parts Div., 4 pp, ill, No. 1P601. Shows Reynolds facilities for research and production of aluminum parts to meet specialized needs. (79)

Wire Screens. John A. Roebling's Sons Co., Woven Wire Fabrics Div., 12 pp, ill, No. W-903. Specifications of company's standard screens for grading uniformly and long life. (80)

Stainless Steel Products. Schnitzer Alloy Products Co., 48 pp, ill, No. 50. Sizes, specifications and corrosion data on such stainless products as machine screws, nuts, pipe and tubing. (81)

Spun Metal Parts. Spincraft, Inc. Data book on metal spinning and fabricating provides much useful design information for the fabrication of parts. (82)

Stainless Steel Castings. The Stainless Foundry & Engineering Co., 4 pp, ill. Shows variety of stainless castings and includes helpful engineering data. (83)

Powder Metal Parts. F. J. Stokes Machine Co., 4 pp, ill, *Stokes News,* Vol. 3, No. 3. Indicates some diverse applications of powder metal parts made by this firm. (84)

Hard Metal Castings. Stoody Co., 15 pp, ill. Description and examples of Stoody Castings with helpful information for ordering custom made parts for uses such as bearings and bushings. (85)

Compression-Formed Tubing. Tube Reducing Corp., 8 pp, ill, No. R-3. Specifications, description and method of making steel compression-formed tubing described. (86)

Steel Castings. Unitcast Corp., Steel Casting Div., folder, No. 1248S. Describes modern facilities for producing and testing high grade molding sand for good steel casting. (87)

Weldments. The Van Dorn Iron Works Co., ill. Information on advantages of weldments and this company's facilities for producing them. (88)

Coatings • Finishes

Zinc, Cadmium Finishes. Allied Research Products, Inc. Describes Iridite finishes for zinc and cadmium in chromium-like, olive green, iridescent and other colors. (89)

Clear Lacquer. Maas & Waldstein Co., No. 110. Recommends Dulac Clear Universal Lacquer No. 462 for retention of desirable metal surface qualities and good adherence. (90)

Metallizing. Metallizing Engineering Co., 4 pp, ill, No. 45A/2M. Case histories and descriptions of three Metcolizing processes indicating protective advantages for typical applications. (91)

Phosphate Coating. Neilson Chemical Co., No. 48-91. Describes Prep-N-Cote, economical phosphate coating for improving corrosion resistance of steel and aluminum surfaces to be painted. (92)

Protective Coating. Nox-Rust Chemical Corp., 4 pp, ill. Describes Nox-Rust 310-AC protective coating for metal parts. Easily applied, said to afford good protection up to 90 days. (93)

Organic Solvents. Solvents & Chemicals

Group. Handbook explains properties and applications of key organic solvents in nontechnical terms. (94)

Protective Coatings. United Chromium, Inc., 4 pp, ill, No. MC-4. Describes four different groups of Ucilon corrosion resistant coatings giving properties, advantages and case histories. (95)

Methods and Equipment

Heat Treating • Heating

Colloidal Graphite. Acheson Colloids Corp., No. 426-18B. Applications of "Dag" Colloidal Graphite as high temperature lubricant for metalworking operations. (96)

Heat Treating Equipment. American Gas Furnace Co. No. C-1303. Catalog shows AGF oven and pot furnaces, flow meters, gas carburizers and other heat treating equipment. (97)

Sintering Furnaces. Harper Electric Furnace Corp., 2 pp, ill, No. 847. Describes two types of high temperature sintering furnace for quality production of powdered metal parts. (98)

Oil Burners. Hauck Mfg. Co., 8 pp, ill, No. 3-M. Advantages, characteristics and limitations of radiant tube heating. Details on burner performance and tube design. (99)

Electric Tube Furnaces. Hevi Duty Electric Co., No. HD1236. Complete specifications and uses of this company's electric combustion tube furnaces. (100)

Heat Treating Furnaces. Holcroft & Co., 4 pp, ill. Features of batch-type, controlled atmosphere furnace shown, including automatic cycle and unit-type construction. (101)

Salt Baths. E. F. Houghton & Co., 32 pp, ill, No. 2-363-C. Properties and features of company's various salt baths indicating wide variety of heat treating applications. (103)

Induction Heating for Brazing. Lepel High Frequency Laboratories, Inc., 8 pp, ill. Details on induction heating units for accelerated brazing of parts. (104)

Heat Treating. Lindberg Engineering Co. *Heat Treating Hints* gives helpful advice on various heat treating operations and methods. (105)

Chain and Belt Conveyors. Michigan Steel Casting Co., 8 pp, ill, No. 1-B. Shows Misco rivetless chain conveyors and Woodman belt conveyors for high temperatures. (106)

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MANUFACTURERS' LITERATURE

Induction Heating. The Ohio Crankshaft Co. Describes plant survey and possible applications to which induction heating might be put for greater production economy. (107)

Heat Treating Accessories. Rolock, Inc., 4 pp, ill, No. 949. Describes use of heat and corrosion resistant alloys in baskets, racks, muffles, retorts, trays, etc. (108)

Heat Treating. Surface Combustion Corp., 8 pp, ill. Vol. 1, No. 1. *Heat Treat Review* describes developments in heat treating methods and equipment. (109)

Metal Conveyor Belts. Wickwire Spencer Steel Div., 24 pp, ill. Construction features and applications of various types of metal and wire conveyor belts for high temperature use. (110)

Electric Immersion Heaters. Edwin L. Wiegand Co., 48 pp. Catalog shows complete line of Chromalox electric heaters, giving applications and specifications. (111)

Cleaning • Finishing

Metal Electrocleaner. The Diversey Corp., 4 pp, ill, No. 49B. Advantages and uses of Diversey No. 12 reverse current electrocleaner for steel, copper and copper alloys. (112)

Power Driven Brushes. The Fuller Brush Co., 32 pp, ill. Describes Fullergript brushes, their application to such processes as scrubbing steel sheet and tampico brushing. (113)

Metal Cleaner. Niagara Alkali Co. Pamphlet gives properties and applications of Nialk Trichlorethylene, said to be high quality, stable metal cleaner and degreaser. (114)

Die Finishing Process. Pangborn Corp., No. 1400. Data on Hydro-Finish die cleaning process, said to remove oxides, cut hand finishing 60%, and maintain 0.0001-in. tolerances. (115)

Industrial Brushes. Pittsburgh Plate Glass Co., Brush Div., Dept W-4, 3221 Frederick Ave., Baltimore, Md. Case histories indicate economies available to users of Pittsburgh brushes. Request on company letterhead direct from this company.

Welding • Joining

Riveting Aluminum. Aluminum Co. of America, 64 pp, ill. Comprehensive riveting data includes information on design and protection of joints, driving methods and selection of rivet alloy. (117)

Resin Adhesive. American Cyanamid Co., 8 pp, ill. Features of Urac 180 resin adhesive, indicating uses in plywood pressing, wood bonding, etc. (118)

Silver Brazing Alloy. American Platinum Works. Physical characteristics and uses of A.P.W. No. 355 silver brazing alloy, closely matching stainless steel in color. (119)

Alloy Welding Electrodes. Arcos Corp., 2 pp, No. 44822. Data on 11 alloy electrodes for fabrication welding and salvage of both high and low alloy castings. (120)

Fasteners. Blake & Johnson Co. Catalog on slotted or Phillips head screws, stove bolts, nuts, rivets, chaplets, special headed products and wire forms. (121)

Pin-Type Fastener. Elastic Stop Nut Corp. of America, 4 pp, ill, No. ADL-5025. Specifications and uses of Esna Rollpins, expandable steel pins said to stay tight permanently. (122)

Welding. Eutectic Welding Alloys Corp., 43 pp, ill, No. 1. Manual describes various welding processes, joining methods and techniques, applications, and gives data on Eutectic Low Melting Alloys. (123)

Welding Electrodes. Eutectic Welding Alloys Corp., 6 pp, ill, TIS 246 P. Several charts give uses, properties and welding information for various low temperature alloys of this company. (124)

Special Fasteners. John Hassall, Inc. Complete line of cold-headed nails, rivets and screws from 1/32- to 3/8-in. dia up to 7-in. lengths in a variety of finishes. (125)

Welding Nickel Alloy. Illium Corp., 4 pp, No. 105B. Instructions for metallic arc and oxyacetylene gas welding of Illium, nickel-base, corrosion resistant alloy. (126)

Materials & Methods, 330 W. 42nd St., New York 18, N. Y.

I should like a copy of each piece of Manufacturers' Literature specified by number circled below. ***We request students to send their inquiries to the manufacturers***

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MANUFACTURERS' LITERATURE

Argon Metal Arc Welding. The Linde Air Products Co., 6 pp, ill, No. F-7416 A. Procedures and equipment for argon metal arc welding, showing advantages and applications. (127)

Brazing Rings. Lucas-Milhaupt Engineering Co., ill. Case history shows advantages of new, patented notched-coil, stress-relieved silver alloy brazing and soldering rings. (128)

Welding Electrodes. McKay Co., chart. Complete comparative listing of this firm's welding electrodes and interchangeable types of other companies. (129)

Screws. Ohio Nut & Bolt Co. Specifications and descriptions of this company's large assortment of screws. (130)

Tightening Self-Locking Nuts. The Palnut Co., 4 pp, ill, No. 554. Methods of driving and tightening Palnut self-locking nuts. Lists specifications of special wrenches. (131)

Self-Locking Set Screws. Set Screw & Mfg. Co. Demonstrator clearly explains principle of this company's Zip-Grip self-locking set screws. (132)

New Fastener. Shakeproof Inc., 16 pp, ill, No. AS-39. Describes Keps, pre-assembled nuts and lock washers claimed to eliminate time-consuming lock washer handling. (133)

Fasteners. Simmons Fastener Corp. Literature describes fasteners especially designed for use in construction where easy demountability is required. (134)

Special Fasteners. South Chester Corp. Describes efficient, easy-to-install fasteners for such applications as fastening panels and frames. Claimed to fit 90% of jobs. (135)

Nut Retainers. Tinnerman Products, Inc., 8 pp, ill, No. 245-3. Specifications and descriptions of Speed Grip nut retainers offering a sure method of keeping nuts secure. (136)

Forming • Casting • Molding Machining

Flame Cutting Machine. Air Reduction Sales Co., No. ADC-660. Features of Airco No. 3 Monograph gas shape cutting machine said to be low in cost, portable, accurate and highly versatile. (137)

Forging. The Drop Forging Assn., 8 pp, ill, Vol. 15, No. 2. *Drop Forging Topics* shows new forging applications indicating advantages and fabricating techniques. (138)

Metal Forming Process. Hydropress, Inc., 8 pp, ill, No. L-58. Detailed description of Marform process for forming accurate sheet metal parts. Applications and cost analysis included. (139)

Die Casting Machines. Kux Machine Co., ill. Catalog shows specifications and applications of complete line of this company's die casting machines. (140)

Hydraulic Presses. Lake Erie Engineering Corp., 12 pp, ill, No. 4.1. Descriptions of several side housing double- and triple-action presses ranging from 150 to 1000 tons. (141)

Tungsten Carbide Rolls. Metal Carbides Corp., 16 pp, No. CR-50. Manual gives information on use and advantages of tungsten carbide rolls for cold rolling metals. (142)

Automatic Molding Machines. F. J. Stokes Machine Co., 20 pp, ill. Describes development, advantages and applications of fully automatic molding machines for thermosetting plastics. (144)

Magnetic Perforating Dies. S. B. Whistler & Sons, Inc., ill. Complete descriptions, prices and applications of this company's magnetic perforating dies. (145)

Inspection • Testing • Control

Hardness Tester. Ames Precision Machine Works, 6 pp, ill. Describes Model 4 precision portable hardness tester for testing rounds and flats up to 4 in. (146)

Ultrasonic Tester. The Brush Development Co., 4 pp, ill. Operating principle and uses of the "Hypersonic" Analyzer for nondestructive inspection of materials. (147)

Industrial Radiography. Eldorado Mining & Refining (1944) Ltd., Dept. W. Manual gives up-to-date information on nondestructive testing of metals by gamma radiography. (148)

Gas Analysis. Charles Engelhard, Inc., 8 pp, ill, No. 800 A. Example solutions of gas analysis problems using this company's equipment. Said to give complete, sensitive analysis. (149)

Glassmeters and Reflectometers. Henry A. Gardner Laboratory, Inc., 8 pp. ill. Features, advantages and applications of portable glassmeters and reflectometers for measurement of surface gloss and reflection. (150)

Microphotometer. Jarrell-Ash Co., No. 1-5. Specifications for Jaco projection comparator microphotometer, with many advantages to the spectrographer. (153)

Universal Testing Machine. National Forge and Ordnance Co., 4 pp, ill, No. 501. Features of two table model testing machines for tension, compression, flexure, shear and transverse tests. (154)

Portable Hardness Tester. Newage International, Inc., No. ET10. Describes Ernst portable hardness tester for direct, accurate readings in Rockwell or Brinell low, medium or high ranges. (155)

Tensile Testing Machines. Scott Testers, Inc., 66 pp, ill, No. 50. Shows wide assortment of testing machines for testing tensile strengths of such materials as rubber, paper, wire and thread. (156)

Hardness Testing Machine. Steel City Testing Machines, Inc., 2 pp, ill, No. H 249. Specifications, operating instructions and description of Model UK-300-H manually operated Brinell Testing Machines. (157)

Moisture Meter. Tagliabue Instruments Div., 4 pp, ill, No. 1263 A. Applications and features of Tag Dielectric Moisture Meter for measuring moisture content of materials such as plastics. (158)

Ceramic Laboratory Ware. The Thermal Syndicate, Ltd. Descriptions, specifications and prices of Vitreosil ware, said to be superior to porcelain in some respects. (159)

Plastics Tests. U. S. Testing Co., Inc., 2 pp. Price list of physical, chemical, microbiological and permanence tests available for plastics film, sheeting and coated fabrics. (160)

General

Materials Controls. Remington Rand, Inc., No. KD367. Booklet describes Kardex system for keeping visible materials and parts inventories coordinated with production. (161)

Foundry Blowers. The Spencer Turbine Co., No. 112. Bulletin describes use of Spencer Turbos as blowers for foundries giving blower features and advantages. (162)

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How the WALES SHEET METAL *Fabricator*

✔ PUNCHES
✔ NOTCHES
✔ NIBBLES *Faster*

Showing operator punching holes in a part with the Wales "Quick-Change" Holder.

Rapid interchangeability for punching, notching and nibbling is one of the outstanding features of the Wales Fabricator that produce such astounding time studies on limited production runs as shown below. Work from blueprints or operation sheets . . . NO TEMPLATES REQUIRED.

For punching, the Wales "Quick Change" Holder permits the interchanging of punches and dies for various round and shaped hole diameters in a matter of seconds. The holder automatically aligns punches and dies.

Wales exclusive Hydra-New-Matic Drive is unique in its simplicity of design and operation . . . so unique, in fact, that vibration and noise are practically eliminated at 165 strokes a minute.

It's too BIG a story to tell on this page, so write for fully-illustrated, functionally-colored Catalog 10-A and discover for yourself why production schedules of this Wales Fabricator have been more than tripled in the last six months.

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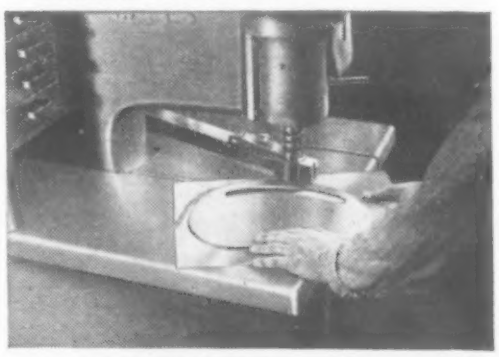
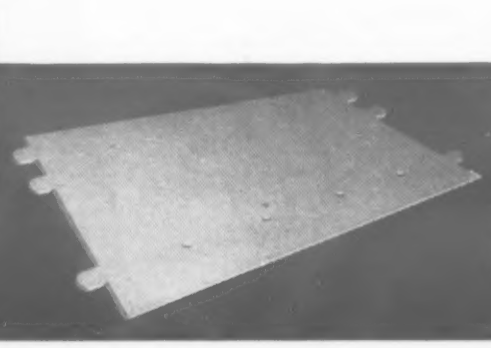
WALES-STRIPPIT OF CANADA, LTD., HAMILTON, ONTARIO
Specialists in Punching and Notching Equipment

Illustrating a Wales Type "NG" Notching Unit in operation in the Wales Fabricator. Note notched corner in the work.



Showing the Wales Fabricator nibbling around the outside of the guide plate. Inside nibbling is accomplished in the same manner.

Can you match this *Time Study?*



This part, 22¼" x 9½", with 4 holes punched and 2 sides notched and nibbled including set-up was produced in only 6.1 minutes and subsequent pieces in only 1.2 minutes.

News Digest

its staff: *Kenneth L. Sayre,* formerly employed by the Standard Ultramarine Co., will carry on experimental and development work on electrochemical projects. *Gordon W. Anderson,* a recent college graduate, will work on mechanical aspects of chemical problems. And *Edward G. Appel,* previously associated with the Girdler Corp., will engage in the application of metallographic techniques in plastics research.

William S. Vaughn, assistant vice president, was appointed a vice president and assistant general manager of the Eastman Kodak Co. At the same time, *M. Wren Gabel* was named assistant vice president and will continue as assistant to the general manager.

Appointment of four men to the research staff of Westinghouse Lamp Div. has been announced. They are: Dr. *Robert B. Windsor,* Dr. *John C. R. Kelly, Jr., Martin F. Quaely* and *Robert Archer.*

Great Lakes Carbon Corp. has named *Robert M. Cook* manager of its newly organized Strata-Crete Sales Div. Mr. Cook previously served as general sales manager of Security Engineering Co.

Dr. *George W. Vinal* has joined The Electric Storage Battery Co. as engineering consultant and advisor. Dr. Vinal recently retired as chief of the National Bureau of Standards' electrochemistry section after more than 42 years with the Government.

The retirement of *David S. Landau,* senior vice president and director, from The Alling & Cory Co. after 41 years of service with the company has been announced. *Charles W. Stuyvesant* succeeds him as vice president and manager.

Wilbur R. Leopold was promoted to the position of assistant vice president of Worthington Pump and Machinery Corp., and will serve on public works projects. *Clarence S. Wentworth* succeeds Mr. Leopold as manager of Worthington's Detroit office.

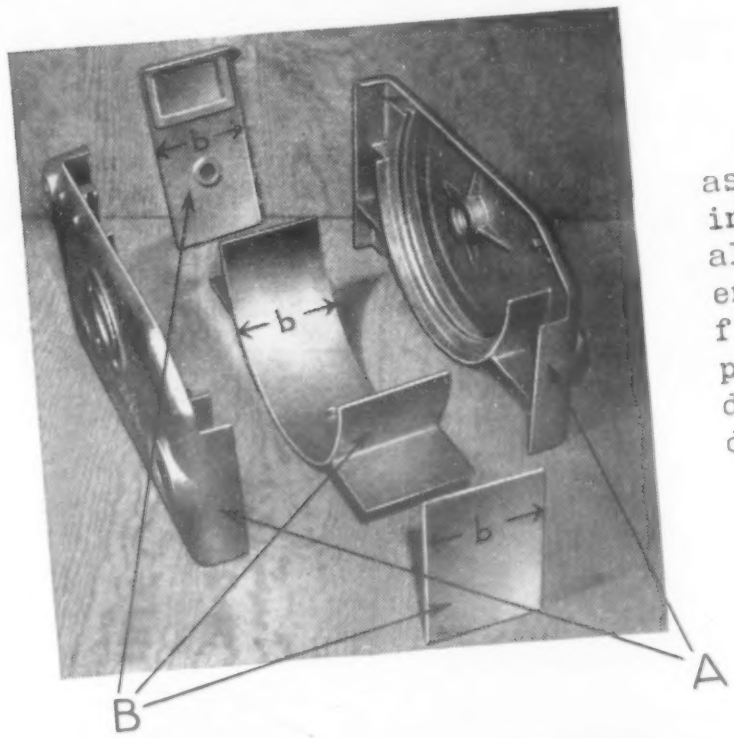
The appointment of *E. A. Erickson,* shop superintendent, as manager of the Hornell, N. Y., plant of SKF Industries, Inc. occurred recently.

Edmund Fitzgerald, president of the Northwestern Mutual Life Insurance Co., has been elected a director of Chain Belt Co. to fill the vacancy created by the death of the late *Walter Kasten.*

H. K. Porter Co., Inc. has promoted *B. C. Blake* from works manager to the position of vice president and general manager of Connors Steel Co., a division of Porter. He succeeds *H. P. Bigler,* who recently resigned. Another appointment was that of *Lawrence L. Garber* as general manager of Porter's American Fort Pitt Spring Div.

Ideas on Welded Design—For the Engineer's Notebook

Design of a coolant separator, made of aluminum, called for production in four different sizes. But what was the secret of making these at high rates and at low costs? Answer — good design, followed by welding. And here is how the job was done:



Only the width was changed as the size of the separator increased, instead of enlarging all dimensions. Identical end pieces, marked "A" were used for all models. Only the center pieces, marked "B," were cast in different widths, with the one dimension, "b," changed.

Next, the cast sections were assembled by HELIARC welding — ideal for aluminum. Here, the HELIARC HW-4 torch is doing the job.

Usual problems of producing complicated castings were eliminated by the design of simple castings and the joining of these parts by HELIARC welding. Rejections were minimized. Result — four different models at high production rate and at low cost.

For additional information about HELIARC welding and other LINDE methods, and for help in solving your production problems, please call our nearest office.

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News Digest

James J. Pilas has become manager of the newly-created Fastener Dept. of Acme Steel Co.

The retirement of *Chester A. Gage* as vice president in charge of sales of National Starch Products, Inc. has been announced. Mr. Gage will, however, remain as director and consultant of the organization.

Harold G. Williams has joined the Lee Mechanical Laboratories as manager of its Beryllium Copper Div. Mr. Williams previously served as chief metallurgist of Instrument Specialties Co.

American Silver Co., Inc. has appointed *Richard Schwarzchild* assistant to the president.

R. E. Moore, vice president and secretary of Bell & Gossett Co., has been elected to the board of directors of Kropp Forge Co.

The promotion of *Carl Bauer* from industrial sales manager to the newly-created post of vice president in charge of industrial sales has been announced by Standard Varnish Works.

Lawrence W. Brennan, Sr. has joined The Warren Refining & Chemical Co. as a vice president. Mr. Brennan previously served as president of The Brooks Boiler Treatment Co.

Charles Engelhard, president of Baker and Co., and an honorary life member of the Board of Trustees of Stevens Institute of Technology, died at the age of 83.

Horizons Inc. has announced the death of Dr. *Jacob L. Snoek* in an automobile accident. Dr. Snoek had been head of the Physics Dept. of Horizons.

The sudden death of *G. Walter Sanborn,* vice president in charge of purchasing and traffic, was announced by the United Engineering and Foundry Co.

News of Companies

Crobalt Inc. has moved into a larger plant at 2800 S. State St., Ann Arbor, Mich. The new building is the first of several units to be erected.

The official name of the *Lupomatic Tumbling Machine Co.,* New York 70, has been changed to *Tumb-L-Matic, Inc.*

Synthane Corp., Oaks, Pa., has moved its New York district office from 233

Glass that Solders to Metal Solves an Engineer's Sealing Problem

Gas and water meter windows once posed a tough little engineering problem—how to get an airtight seal between the window and the metal frame. The answer was found at Corning in PYREX brand glass windows with metallized edges which can be soldered directly to the meter housing. This results in a hermetic seal, eliminating danger of leakage, reducing corrosive action and preventing condensation inside the meter.

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Hermetically sealed windows are but one application. In the field of electronics, high frequency inductances, bushings and capacitors, this same principle is applied. Perhaps you have a problem that can be solved by this development or one of the thousands of Corning's glass compositions. It will pay you to investigate.

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News Digest

Broadway to larger quarters at 125 Parkway Rd., Bronxville, N. Y.

A new plant for the manufacture of Micarta will be opened shortly by *Westinghouse Electric Corp.* at Hampton, S. Car.

Tennessee Eastman Corp., Kingsport, Tenn., wholly-owned subsidiary of *Eastman Kodak Co.*, has been dissolved as a separate corporation and is now a division of the parent company. The official name of the organization is *Tennessee Eastman Co., Div. of Eastman Kodak Co.*

The purchase of the Buna-N synthetic rubber plant of Esso Standard Oil Co. in Baton Rouge, La., by *United States Rubber Co.* has been disclosed. The plant will be operated by the Naugatuck Chemical Div. of U. S. Rubber.

Sterling Bolt Co. has moved its offices and warehouse from 4646 W. Lake St. to new and larger quarters at 363-405 W. Erie St., Chicago.

Purchase of *The William Leard Corp.'s* plant in New Brighton, Pa., from the *Harkit Corp.* has been announced by *The Heppenstall Co.*, Pittsburgh. Work in the New Brighton plant will be coordinated with production of the firm's Pittsburgh works, but there will be no change in personnel.

Worthington Pump and Machinery Corp., Harrison, N. J., has acquired *Wintroath Pumps Inc.*, Alhambra, Calif. The new addition will operate as a wholly-owned subsidiary of Worthington, continuing under present management with Boyd Kern remaining as president.

A new plant designed for the production of benzene hexachloride is being constructed at Natrium, W. Va., by the Columbia Chemical Div. of *Pittsburgh Plate Glass Co.* Completion date of the new plant should be during March or April of this year, but inability of equipment manufacturers in meeting delivery schedules might delay placing the new facility in production.

Merger of the *Edgar E. Brosius Co.*, Pittsburgh, and the *Salem Engineering Co.*, Salem, Ohio, has been announced. They will be known as *Salem-Brosius Inc.*, but both companies will continue to use their individual company identifications for business purposes.

Fisher Scientific Co. has opened a new plant at 7722 Woodbury Dr., Washington, D. C., which will serve as a stocking, shipping and repair center for the Atlantic Seaboard area.

Offices and laboratory of *W. C. Dillon & Co., Inc.*, have been transferred from 5410 W. Harrison St., Chicago, to new quarters at 1421 S. Circle Ave., Forest Park, Ill.

The Wellman Engineering Co., Cleveland, has purchased the property and

News Digest

business of the *Anker-Holth Manufacturing Co.*, Port Huron, Mich. The company will now be known as the *Anker-Holth Div.* of Wellman, with its headquarters remaining in Port Huron. J. C. Hodge, executive vice president of Wellman, will supervise the newly-acquired division.

The acquisition of the *Delta Star Electric Co.*, Chicago, by *H. K. Porter Co., Inc.*, Pittsburgh, has been announced. No change in the operations or management of Delta Star Electric is contemplated.

Optimus Equipment Co., Matawan, N. J. has purchased the trademarks, patents, sales rights, etc., of the *Circo Products Corp.*, Cleveland. The Circo manufacturing operations will be moved to Matawan immediately, where the manufacture and sale of Circo equipment and degreasers will be carried on as the Circo Div. of Optimus. The present Circo distribution and set-up will be continued and expanded.

Purchase of a site in Butler, Pa., for the erection of a plant to manufacture oxygen and nitrogen, together with related facilities, has been announced by *Air Reduction Sales Co.*, New York 17. The new plant is expected to be in operation the latter part of 1951.

United States Radiator Corp., Detroit 26, has purchased the business and assets of the *Cyclotherm Corp.*, Oswego, N. Y. Cyclotherm will be operated as a division of U. S. Rubber, and no change in its products or methods of distribution is contemplated.

Ladish Co., Cudahy, Wis., has established a branch office at 405-406 Thompson Bldg., Tulsa, Okla. At the same time, it was announced that its St. Louis, Mo., office was moved to new quarters in the Continental Bldg., 3615 Olive St.

Formation of an Electromechanical Div. has been announced by *Atlantic Research Corp.*, Alexandria, Va. The new division will be headed by James W. Fitzgerald.

Fort Duquesne Steel Co. has acquired a warehouse building adjacent to its Pittsburgh, Pa., warehouse, doubling the floor area of the plant.

All equipment, patents and production rights to manufacture Starbilt storage equipment has been purchased by *Midland Manufacturing Co.*, Wichita, Kan., from *Star Manufacturing Co.*, Oklahoma City, Okla. A modern steel building is presently under construction in Wichita, and full production is expected this month. The storage equipment will continue to be manufactured under the trade name Starline.

Johnson Plastic Corp. has acquired a new plant on Brown Rd., Chagrin Falls, Ohio. The previous Johnson plant, also located in Chagrin Falls, will continue to

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News Digest

be operated as part of the overall company facilities.

A large contract to build a complete coke oven plant and steel making facilities has been awarded to *Koppers Co., Inc.* by *Republic Steel Corp.*, Pittsburgh, Pa. The new plant, to be built adjacent to Republic's Cleveland District Works, is expected to be in full production by Jan. 1, 1952.

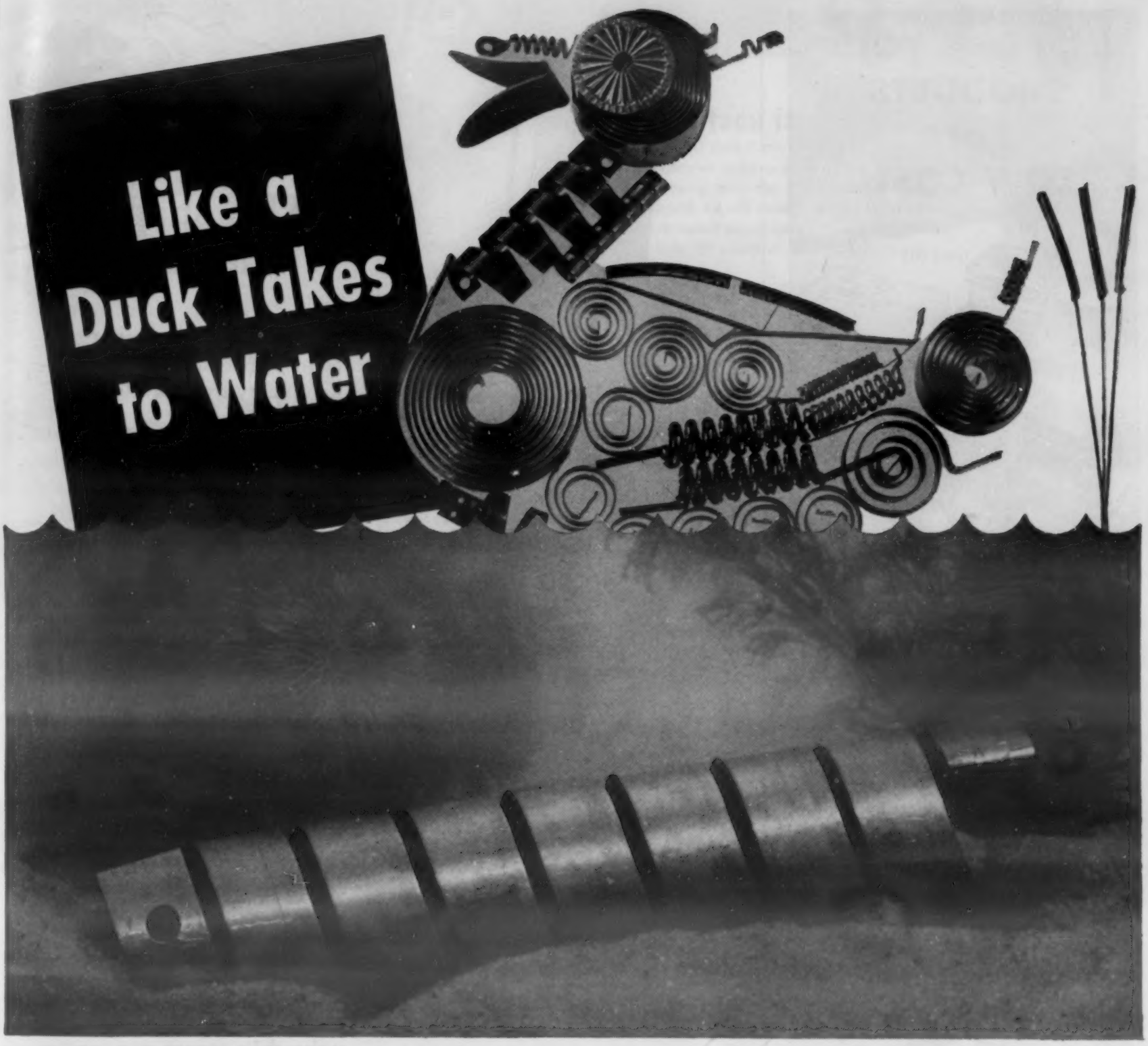
News of Societies

The *National Electrical Manufacturers Assn.* elected the following officers for the coming year: president—C. W. Higbee, United States Rubber Co.; vice presidents —Arthur A. Berard, Ward Leonard Electric Co.; J. H. Jewell, Westinghouse Electric Corp.; J. F. Lincoln, The Lincoln Electric Co.; and R. E. Murphy, I-T-E Circuit Breaker Co.; secretary—Alan F. Sheldon, Kennecott Wire & Cable Co.; and treasurer—L. G. Hall, Stackpole Carbon Co.

Frank Thornton, Jr., engineering manager, Association Activities, Westinghouse Electric Corp., was awarded the James H. McGraw Award, Manufacturers Medal for 1950 during the meeting of the *National Electrical Manufacturers Assn.* The award was presented to Mr. Thornton in recognition of his distinguished contribution to the advancement of the electrical industry in the field of standardization, code development and safety regulations.

F. Warren Bickel, technical director of the Diamond Wire and Cable Co., has been named project leader in a new rubber research laboratory at *Armour Research Foundation* of the *Illinois Institute of Technology.*

The Society of Automotive Engineers (Detroit Section) has announced the establishment of the Henry Ford Memorial Award for the encouragement of younger engineers. Eligibility is restricted to members of the SAE who are under 33 years of age. The Award will be made to the author of an original paper which has been presented, or is suitable for presentation, to an SAE meeting, the paper being limited to subjects related to automotive ground vehicles. Members desiring to compete may secure copies of a brochure giving detailed information from their local SAE Section, or by writing directly to the Detroit Section, Society of Automotive Engineers, 100 Farnsworth, Detroit 2, Mich.



Truflex J7 THERMOSTAT METAL Resists Water Corrosion

General Plate Truflex J7 Thermostat metal takes to water like a duck. For instance, the coil shown above has operated in a hot water tank over 8 years, yet not a single spot in the metal showed corrosion.

In addition to the application above, Truflex J7 Thermostat metal is operating successfully without corrosion in such applications as water mixing valves (shower mixing valves), hot water temperature measuring valves, tanning applications which often require operation in mild acids, radiator valves, etc.

Truflex J7 is but one of the many thermostat metals manufactured to meet specific requirements by General Plate. In fact, Truflex Thermostat metals are available in a complete line of combinations to meet all applications in temperature range, electrical resistance, size, shape and cost. They can be had in raw stock in sheets and coils . . . or as completely fabricated parts ready for assembly into your products. Each and every part is identical in tolerances, expansion, hardness, etc.

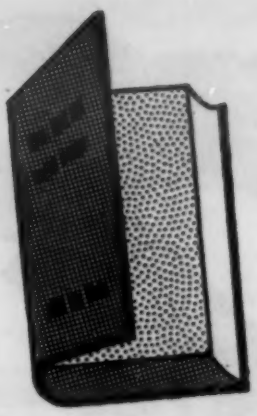
It will pay you to investigate General Plate Truflex Metals for your thermostat requirements. Write for information or engineering assistance.

Other General Plate Products Include — Precious to base metal laminations . . . Base metal laminations . . . Alcuplate (copper and aluminum) . . . silver solders . . . Laminated contacts, buttons, rivets . . . Platinum-fabrication-refining . . . Age-hardening Manganese Alloy 720.

GENERAL PLATE

Division of Metals and Controls Corporation

602 FOREST STREET, ATTLEBORO, MASS.



BOOK REVIEWS

LABORATORY DESIGN. *Edited by H. S. Coleman. Published by Reinhold Publishing Corp., New York 18, N. Y., 1951. Cloth, 9 by 12 in., 393 pages. Price $12.00.* The answers to many problems that must be solved to design a successful industrial or university research laboratory are presented in this report of the Committee on Design, Construction and Equipment of Laboratories of the National Research Council.

SAFETY IN ELECTRIC AND GAS WELDING AND CUTTING OPERATIONS. *Published by the American Welding Society, New York 18, N. Y., 1950. Paper, 6 by 9 in., 42 pages. Price 50c.* American Standard Z49.1-1950, prepared by the American Standard Association Sectional Committee Z49 under A.W.S. sponsorship, covers regulations for the safe installation and operation of welding equipment for all arc, gas and resistance welding processes.

METALLIC AND NON-METALLIC COATINGS FOR GRAY IRON. *By C. O. Burgess. Published by the Gray Iron Founders' Society, Inc., Cleveland 14, Ohio, 1950. Paper, 6 by 9 in., 67 pages. Price* $1.75 for single copy requests. A preprint of the material that will constitute Chapter 8 of the forthcoming "Gray Iron Handbook," which is being prepared by the Technical Dept. of the Gray Iron Founders' Society, Inc. This booklet covers the metallic and nonmetallic coatings that have been successfully applied to gray iron on a commercial scale to meet appearance, corrosion, wear or other requirements. A discount will be offered to those requesting this preprint in quantity.

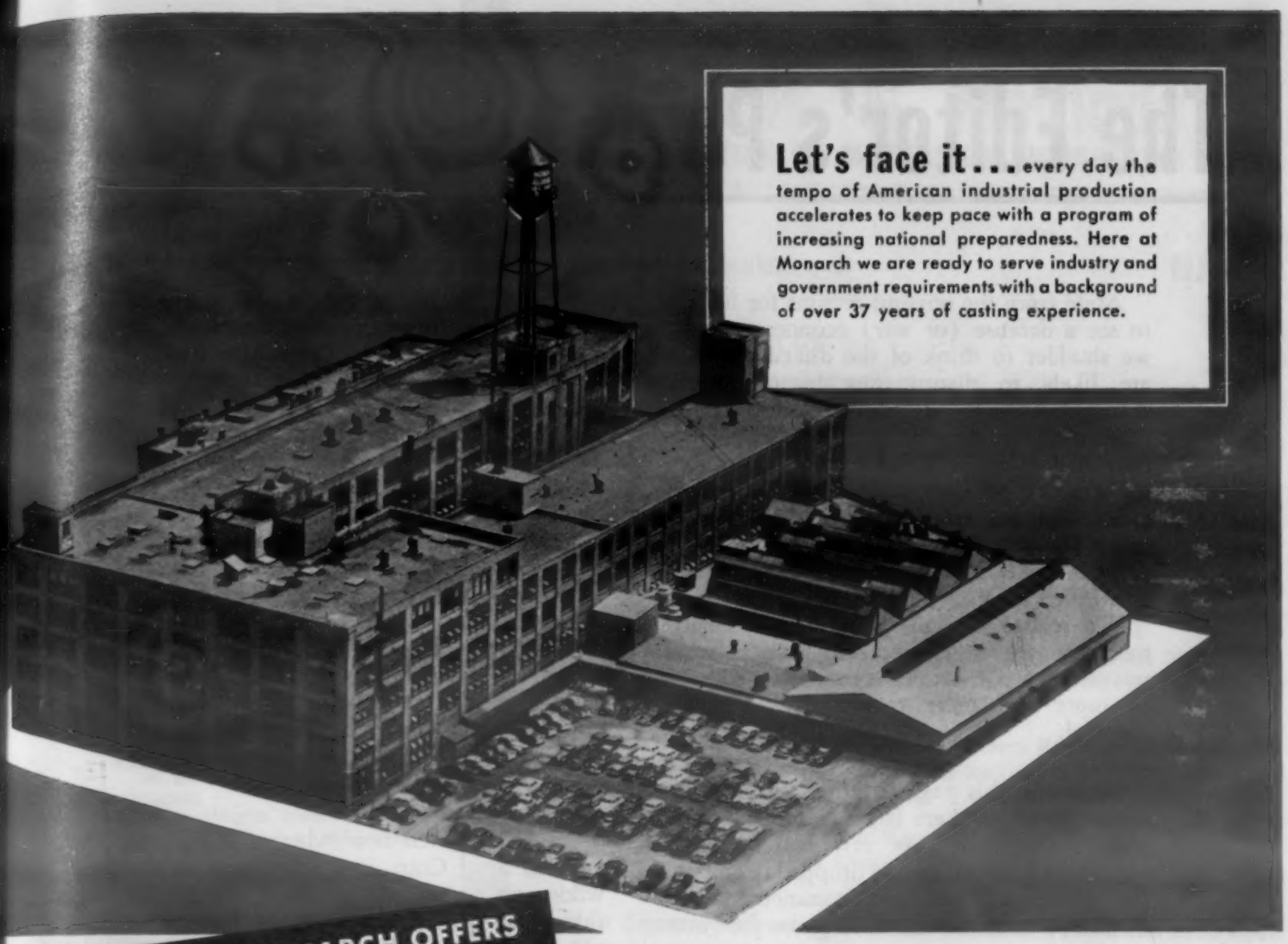
MATERIALS OF CONSTRUCTION FOR CHEMICAL PROCESS INDUSTRIES. *By James A. Lee. Published by McGraw-Hill Book Co., New York 18, N. Y., 1950. Cloth, 6¼ by 9¼ in., 468 pages. Price $6.50.* A valuable guide to selecting construction materials which resist chemical corrosion most efficiently.

TINPLATE HANDBOOK. *By W. E. Hoare. Published by the Tin Research Institute, Inc., Columbus 1, Ohio, 1950. Paper, 6¼ by 9¼ in., 31 pages. Free of charge.* All the facts and information buyers and users are likely to require are included, as well as an English-French-German-Spanish glossary of the technical terms of the trade.

RECOMMENDED PRACTICES FOR SALVAGING AUTOMOTIVE GRAY IRON CASTINGS BY WELDING. *Published by the American Welding Society, New York 18, N. Y. 1950. 19 pages. Price 50c.* The methods used for automotive repairs should be helpful as a guide in establishing methods of repair for other types of castings.

PRACTICAL MICROSCOPY. *By L. C. Martin and B. K. Johnson. Published by the Chemical Publishing Co., Inc., Brooklyn 2, N. Y., 1950. Cloth, 124 pages. Price $2.50.* The technique of modern microscopy—including ultraviolet microscopy and the use of the electron microscope—is covered in detail.

THE ROLLING OF METALS—THEORY AND EXPERIMENT. VOLUME 1. *By L. R. Underwood. Published by John Wiley & Sons, Inc., New York 16, N. Y., 1950. Cloth, 6 by 9 in., 344 pages. Price $6.50.* A connected, critical account of the principles of rolling flat metals, as revealed by recent theoretical and experimental investigations, and indicates their bearing on practical rolling problems.



Let's face it . . . every day the tempo of American industrial production accelerates to keep pace with a program of increasing national preparedness. Here at Monarch we are ready to serve industry and government requirements with a background of over 37 years of casting experience.

HERE'S WHAT MONARCH OFFERS

. . . 300,000 square feet of manufacturing area devoted entirely to the production of ★ Aluminum Permanent Mold Castings ★ Aluminum Die Castings ★ Zinc Die Castings.

. . . Monarch pioneered in the development of aluminum permanent mold castings and today offers the most modern permanent mold production methods.

. . . Monarch also offers a modern die casting division devoted exclusively to precision casting of aluminum and zinc.

. . . Monarch coordinates the production of both permanent mold and die castings under the supervision of two completely staffed engineering departments to assure sound, economical casting design.

. . . Monarch uses complete physical and metallurgical laboratory facilities to maintain highest quality control methods and inspection standards.

. . . Monarch services include finishing and assembly operations for individual permanent mold and die castings or complete product assembly.

. . . Monarch offers modern, company-owned toolroom, maintenance and warehousing facilities within a plant that is strategically located for rail, air or truck shipment.

Here at Monarch we welcome the opportunity to work with you in giving the widest possible casting service, utilizing the full scope of our unique casting facilities.

NOTE: This advertisement forms the nucleus of an interesting folder giving the complete story of Monarch's facilities. We will forward this folder upon request.

ONARCH ALUMINUM MFG. COMPANY • *Detroit Avenue at W. 93rd Street • Cleveland 2, Ohio*

The Editor's Page

Aside from the obvious reasons for hating to see a defense (or war) economy return, we shudder to think of the difficulties that are likely to disrupt our future travels throughout the country and make life a little more disagreeable than normal. Already we have had to wait all day for a hotel room; the scramble for taxis is more hectic in many cities; and, our relatively simple entry into many plants is becoming once more a maze of phone calls, signed statements, passes and uniformed escorts.

We realize that many of these security measures are necessary, but to one who travels a fair portion of his time, the prospect of more and more red tape is not too cheerful.

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By intent, this page is rather informal in nature. Even so, there is no reason why the reader's time cannot be rewarded by little nuggets of wisdom casually dropped in among the grains of wit and comment. This month there are several little gems for your attention:

For instance:

The American Society of Mechanical Engineers recently made the assertion that the U. S. has a very high production rate of something for which it should not claim any credit. According to the ASME, our industry turns out, in an average year, over $3,000,000,000 worth of defective products.

Perhaps one of the limitation orders issuing from the NPA should be applied to this product. I'm sure no one would take issue with even a 100% reduction.

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While some politicians tell us that business as usual is out of the question, others seem to feel that politics as usual is entirely reasonable. What's sauce for the goose, apparently is unsavory for the gander.

Copper and the tariff is a case in point.

Presently we are facing the most critical shortage of copper ever to hit us. Even during periods of more normal usage we depend upon foreign sources for about one-third of our supply. Despite these facts, Congress has, since the start of war in Korea, failed to lift the import duty of $40 a ton on this vital metal. Politics has resulted in many impossible provisions being tacked on to any bills suspending this tariff so as to make them completely unacceptable.

Among our recent travels was a trip to Detroit to eye the engineering marvels being displayed by the Chrysler Corp. After looking goggle-eyed and yearningly at all the shiny new cars on display, we looked at displays showing the routine activities of the company. It is perhaps not at all surprising that we were impressed with the materials engineering activities of Chrysler. As with most other companies, the selection and application of engineering materials are of ever increasing importance to this automobile builder. To give you some idea, Chrysler engineers have compiled 14 volumes of materials standards. The materials covered in the volumes are provided by, or normally available from, more than 3100 approved sources.

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It's hard to tell now whether Allegheny Ludlum Steel Corp. is a lone voice in the wilderness or not. At any rate, the powers that be in A-L decided that the Hollywood trend in glamorizing annual reports had gone just about far enough. Consequently stockholders of the company were polled as to their preference and about 60% of the returns indicated desire for plain, unadorned facts. Perhaps there still is a place in this world for plain, simple things. After all, though, there should be, for the world is crowded with plain, simple people.

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Metals have contributed to human welfare in many ways, but new knowledge indicates that certain metals might hold the key to human health. According to the *Industrial Bulletin* of Arthur D. Little, Inc., we can add barium, titanium, lithium and rubidium to the already recognized supply in humans of copper, manganese, zinc, silver, cobalt and strontium. Lacks and unbalances of these metals may be the cause of such ailments as nervous disorders, lameness or anemia. Plant life needs many of the same metals for healthy growth.

Even with only an estimated 0.5% of the mass of the human body being composed of these metals, there is a strong possibility that the long accepted value of the human body be increased from ninety-some cents to at least a dollar and a half.

T. C. Du Mond
Editor